Technological Issues

A Standards-Based High School Model Course Guide

Engineering By Design

Advancing Technological Literacy

A Standards-Based Program Series

DRAFT Guide

April, 2005

INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION

CENTER TO ADVANCE THE TEACHING OF TECHNOLOGY & SCIENCE

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Table of Contents

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Preface

Engineering By Design – A Standards-Based Approach

In 2004, the International Technology Education Association's (ITEA) Center to Advance the Teaching of Technology and Science (CATTS) began development of the Engineering By Design Program, of which the *Foundations of Technology* guide is one component. The Program is described in detail later in the chapter and has been written so that you, as the teacher, supervisor, principal, or teacher educator can implement or develop standards-based instruction. The reader will find that the entire Program is described so that a sense of the overall approach to developing technological literacy through the study of Technology, Innovation, Design and Engineering (TIDE) in Grades K-12 can be seen.

More than anything else, the program has been developed through a process that is based on standards. Each course in the Program focuses on one organizing principle that was developed based on the *Standards for Technological Literacy (STL)*. As the reader and implementer, you will find that the approach is significantly different than the traditional "find the activities then develop the content" method. To be truly standards-based, the Program must be created around standards and benchmarks—not a series of activities. This guide is the first of many to be produced that will do just that, so that the assessments that are introduced can be used appropriately by educators to inform instruction and improve student achievement.

It is the goal of this guide to provide educators with a model for implementing a standards-based program and course. Each section will be related to standards and will use the forms that can be found in the ITEA Technological Literacy Standards Series and the supporting Addenda Guides.

This guide presents content and lessons in a cornerstone technology education model course for the high school. It is based on *Technology for All Americans: A Rationale and Structure for the Study of Technology (Rationale and Structure)* (ITEA, 1996) and *Standards for Technological Literacy: Content for the Study of Technology (Standards for Technological Literacy/STL)* (ITEA, 2000/2002). Further guidance is provided through *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL)* (ITEA, 2003). Because these ITEA publications contain the fundamentals of technological literacy curriculum, teachers, supervisors, and teacher educators are encouraged to review them prior to using this guide.

Technology for All Americans: A Rationale and Structure for the Study of Technology

Technology for All Americans: A Rationale and Structure for the Study of Technology provides a vision for the study of technology. It addresses the power and promise of technology and the need for every American student to be technologically literate when he/she graduates from high school. Understanding the nature of technological advances and processes and participating in society's decisions on technological issues is of utmost concern. This publication outlines the knowledge, processes, and contexts for the study of technology.

Standards for Technological Literacy: Content for the Study of Technology

What is *Standards for Technological Literacy*?

ITEA and TfAAP published *Standards for Technological Literacy: Content for the Study of Technology (STL)* in April of 2000. *STL* defines, through K-12 content standards, what students should know and be able to do in order to be deemed technologically literate. However, it does not put

forth a curriculum to achieve these outcomes. *STL* will help ensure that all students receive an effective education about technology by setting forth a consistent content for the study of technology.

Why is *STL* important?

- Technological literacy enables people to develop knowledge and abilities about human innovation in action.
- *STL* establishes requirements for technological literacy for all students from kindergarten through Grade 12.
- *STL* provides expectations of academic excellence for all students.
- Effective democracy depends on all citizens participating in the decision-making process; many decisions involve technological issues, so citizens need to be technologically literate.
- A technologically literate population can help our nation maintain and sustain economic progress.

Guiding Principles for *STL*

The standards and benchmarks were created with the following guiding principles:

- They offer a common set of expectations for what students should learn about technology.
- They are developmentally appropriate for students.
- They provide a basis for developing meaningful, relevant, and articulated curricula at the local, state, and provincial levels.
- They promote content connections with other fields of study in Grades K-12.
- They encourage active and experiential learning.

Who is a technologically literate person?

A person who understands—with increasing sophistication—what technology is, how it is created, how it shapes society, and in turn, how technology is shaped by society, is technologically literate. A technologically literate person can hear a story about technology on television or read it in the newspaper and evaluate its information intelligently, put that information in context, and form an opinion based on it. A technologically literate person is comfortable with and objective about the use of technology—neither scared of it nor infatuated with it. Technological literacy is important to all students in order for them to understand why technology and its use is such an important force in our economy. Anyone can benefit by being familiar with it. All people, from corporate executives to teachers to farmers to homemakers, will be able to perform their jobs better if they are technologically literate. Technological literacy benefits students who will choose technological careers—future engineers, aspiring architects, and students from many other fields. Students have a head start on their future with an education in technology.

What is included in *STL*?

There are 20 content standards that specify what every student should know and be able to do in order to be technologically literate. The benchmarks that follow each of the broadly stated standards at each grade level articulate the knowledge and abilities that will enable students to meet the respective standard. A summary of the content standards and benchmarks is presented in Appendix A of this document. Teachers are encouraged to obtain *STL* to review the benchmarks associated with each standard.

Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL)

While the *Rationale and Structure for the Study of Technology* provides a vision and *Standards for Technological Literacy: Content for the Study of Technology* provides the content, neither was designed to address other important elements that are critical to a comprehensive program of technological studies. As a result, ITEA's Technology for All Americans Project published *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL)*. *AETL* is currently available from ITEA and is designed to help schools implement new strategies and evaluate existing practices of assessing students for technological literacy, providing professional development for teachers and other professionals, and improving programs of teaching and learning.

Advancing Technological Literacy: ITEA Professional Series

The Advancing Technological Literacy: ITEA Professional Series is a set of publications developed by the International Technology Education Association (ITEA) based on *Standards for Technological Literacy* (ITEA, 2000/2002) and *Advancing Excellence in Technological Literacy* (ITEA, 2003). The publications in this series are designed to assist educators in developing contemporary, standards-based K-12 technology education programs. This exclusive series features:

- Direct alignment with technological literacy standards, benchmarks, and guidelines.
- Connections with other school subjects.
- Contemporary methods and student activities.
- Guidance for developing exemplary programs that foster technological literacy.

Titles and resources in the series include:

Technological Literacy Standards Series

- *Standards for Technological Literacy: Content for the Study of Technology*
- *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards*
- *Technology for All Americans: A Rationale and Structure for the Study of Technology*

Addenda to Technological Literacy Standards Series

- *Realizing Excellence: Structuring Technology Programs*
- *Developing Professionals: Preparing Technology Teachers*
- *Planning Learning: Developing Technology Curricula*
- *Measuring Progress: A Guide to Assessing Students for Technological Literacy*

Engineering By Design: Standards-Based Program Series

Elementary School Resources

- *Technology Starters: A Standards-Based Guide*
- *Models for Introducing Technology: A Standards-Based Guide*

Middle School Resources

- *Teaching Technology: Middle School, Strategies for Standards-Based Instruction*
- *Exploring Technology: A Standards-Based Middle School Model Course Guide*
- *Invention and Innovation: A Standards-Based Middle School Model Course Guide*
- *Technological Systems: A Standards-Based Middle School Model Course Guide*

High School Resources

- *Teaching Technology: High School, Strategies for Standards-Based Instruction*
- *Foundations of Technology: A Standards-Based High School Model Course Guide*
- *Engineering Design: A Standards-Based High School Model Course Guide*

- *Impacts of Technology: A Standards-Based High School Model Course Guide*
- *Technological Issues: A Standards-Based High School Model Course Guide*

Engineering By Design: Standards-Based Technological Study Lessons

Elementary School Resources

- Kids Inventing Technology Series (KITS)

Elementary/Middle School Resources (Grades 5-6)

- Invention, Innovation, and Inquiry (I^3) Lessons
  - Invention: The Invention Crusade
  - Innovation: Inches, Feet, and Hands
  - Communication: Communicating School Spirit
  - Manufacturing: The Fudgeville Crisis
  - Transportation: Across the United States
  - Construction: Beaming Support
  - Power and Energy: The Whispers of Willing Wind
  - Design: Toying with Technology
  - Inquiry: The Ultimate School Bag
  - Technological Systems: Creating Mechanical Toys

Secondary School Resources

- Humans Innovating Technology Series (HITS)
- Project ProBase – Engaging Technology Lessons
  - Agriculture and Related Technologies
  - Construction Technologies
  - Energy and Power Technologies
  - Entertainment and Recreation Technologies
  - Information and Communication Technologies
  - Manufacturing Technologies
  - Medical Technologies
  - Transportation Technologies

The Center to Advance the Teaching of Technology and Science: ITEA-CATTS

The International Technology Education Association's Center to Advance the Teaching of Technology and Science (ITEA-CATTS) was created to provide curriculum and professional development support for technology teachers and other professionals interested in technological literacy. ITEA-CATTS initiatives are directed toward four important goals:

- Development of standards-based curricula
- Professional development through learning communities
- Research on teaching and learning
- Curriculum implementation and diffusion

The Center addresses these goals to fulfill its mission to serve as a central source for quality professional development support for the teaching and learning of technology and science.

ITEA-CATTS Consortium was established as part of ITEA-CATTS to form professional leadership and alliances in order to effectively enhance teaching and learning about technology and science. Consortium members receive quality curriculum products and professional development based on the standards. This publication was conceptualized and developed through the ITEA-CATTS Consortium.

Pathways and Career Clusters

The Engineering Design Program has been designed with current research on the development of smaller learning communities around career-themed academies as the guiding principle. While technology education courses are not based on preparing students with vocational skills, they are preparing students for the global workplace by ensuring that they are technologically literate.

Scenario:

As schools work through a planning process to determine what types of Academies will be offered to students, they begin to look at the strengths of the community and the school. School leadership teams identify between three and six themes built on the career-cluster model. Research shows that these themes should identify one academy for every 250-300 students in a school. The concept of the academy uses a team of teachers to present the content around the theme. So, if the career-themed academy is Arts and Media, then all of the teachers identified in that academy plan their content around the Arts and Media theme. While some schools identify the theme that is directly related to a career cluster name, many do not. Some common Academy themes include: Arts & Media, Business & Finance, Entrepreneurship, Theatre, Science & Technology, Social Science, Human Services, Engineering, and International Studies.

In each of these examples, technology education and the delivery of technological literacy is critical to the success of students in their future. The courses Impacts of Technology and Technological Issues are written in such a way that the framework for content can be centered around any of the listed academy themes. A course in Technological Issues can easily be focused (given the way the product is written) on International Studies, etc. This makes them a valuable part of the articulated sequence of courses that students take in their academy focus. These courses emulate the transferability necessary in a world where changing technology impacts our everyday life and creates issues for society.

Using This Guide

This guide provides standards-based content, activities, and resources for teaching a cornerstone technology course at the high school level. The information contained in this guide will assist teachers in preparing to implement *STL*. In addition, it can be used by state, provincial, and local curriculum developers in creating standards-based curriculum.

The **Introduction** section addresses the Engineering By Design Program and how it was conceived to be standards-based. States, school districts, and schools will find that this chapter is a model for designing a program that teaches technological literacy that is truly standards-based. Each model uses the processes and forms that are prescribed in the ITEA Addenda Guides, *Planning Learning: Developing Technology Curricula*, and *Realizing Excellence: Structuring Technology Programs*.

The **Overview** features an introduction to *Technological Issues*, course information, and goals and objectives. The use of a pre- and post-assessment is discussed, as well as examples of assessment items. A Course Content Outline is provided with the units of instruction for this course.

Units 1-5 provide the units of instruction in detail for use by the classroom teacher. Each unit presents standards-based content for students in the Technological Issues Course. The unit framework consists of an overview, standards/benchmarks, the BIG Idea for the unit, assessment tools, lessons, and learning activities that include teacher preparation, unit content, suggested learning activities, assessment, and resources.

The **Appendix** contains descriptions of resources, materials, and references that teachers may obtain as they develop curriculum and instructional materials. Teachers, curriculum developers, and other interested readers are encouraged to review the guide in its entirety. The content across the chapters and instructional units collectively contributes to quality instruction that addresses the standards.

Introduction
Engineering by Design: Model Program

Engineering By Design
A National Model for Standards-Based Programs

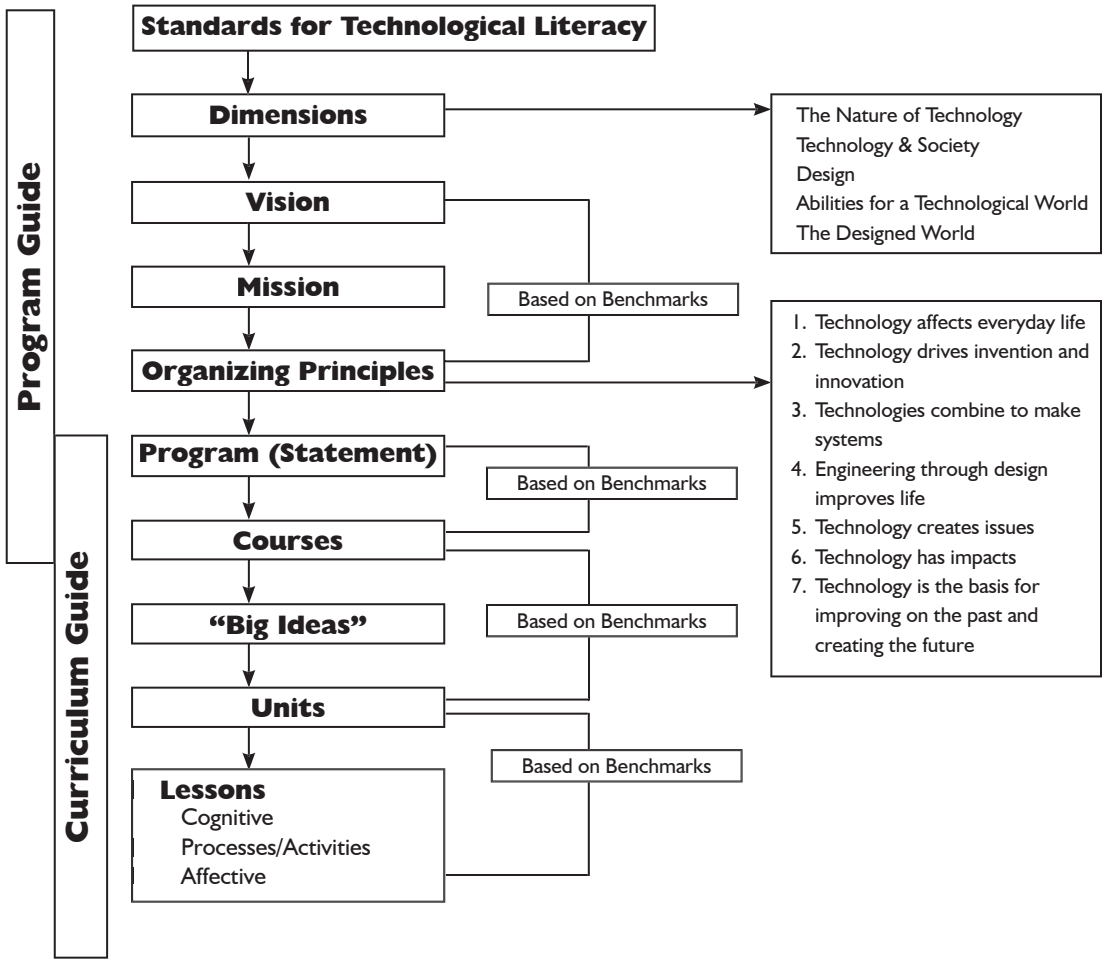
Introduction

Engineering By Design is a National Model Program that was developed in collaboration and consultation with the ITEA-CATTS Consortium, Technology Education Advisory Council, ITEA Institutional Members, and the Mathematics, Science, and Engineering Communities. The reader will see, as the structure of the program unfolds, that the intent is related to the development of technological literacy for students in Grades K-12 and delivered in the context of Technology, Innovation, Design, and Engineering (TIDE.)

States, districts, and schools may wish to use this chapter as the basis for the development of a new program in TIDE, or to use it just as it is written. Note that either way, the assessments that are used in the Program and in this course are designed specifically to measure achievement of the *STL* technological literacy standards and corresponding benchmarks.

Engineering-By-Design
A National Standards-Based Program Model*
ITEA's Center to Advance the Teaching of Technology and Science

* This model is based upon the model and process published in ITEA's addendum to the technological literacy standards in *STL* and *AETL*, *Realizing Excellence: Structuring Technology Programs* (2005c).



The Vision – Engineering By Design

We live in a technological world. Living in the twenty-first century requires much more from every individual than a basic ability to read, write, and perform simple mathematics. Technology affects every aspect of our lives, from enabling citizens to perform routine tasks to requiring that they be able to make responsible, informed decisions that affect individuals, our society, and the environment. Citizens of today must have a basic understanding of how technology affects their world and how they exist both within and around technology.

Technological literacy is fundamentally important to all students. Technological processes have become so complex that the community and schools collaborate to provide a quality technology program that prepares students for a changing technological world that is progressively more dependent on an informed, technologically literate citizenry.

The Mission – Engineering By Design

The ITEA model technology program is committed to providing technological study in facilities that are safe and facilitate creativity, enabling all students to meet local, state, and national technological literacy standards. Technological study is required in sixth, seventh, and eighth grades. Students are prepared to engage in additional technological study in the high school years and beyond. Students will be prepared with knowledge and abilities to help them become informed, successful citizens who are able to make sense of the world in which they live. The technology program also enables students to take advantage of the technological resources in the local community.

The Organizing Principles

The program consists of seven organizing principles. These principles are very large concepts that identify major content organizers for the program. As stated earlier, Engineering By Design is to be taught in the context of Technology, Innovation, Design, and Engineering. In order of importance, the seven identified organizing principles are listed below:

1. Engineering through design improves life.
2. Technology has and continues to affect everyday life.
3. Technology drives invention and innovation and is a thinking and doing process.
4. Technologies are combined to make technological systems.
5. Technology creates issues that change the way people live and interact.
6. Technology impacts society and must be assessed to determine if it is good or bad.
7. Technology is the basis for improving on the past and creating the future.

Program Descriptions

The program statement on which the courses are developed is based on the identification of benchmarks for each organizing principle. (Note that the number of courses does not necessarily have to be the same as the number of organizing principles—there may be more than one organizing principle for each course.)

Engineering By Design: District/State Level Program Description

This program provides students with a foundation in the role of technology in everyday life, along with a broad range of technology skills that make them aware of technology around them. Students completing the program will become technologically literate by learning the concepts and role that engineering, design, invention, and innovation have in creating technology systems that help make life easier and better. Students learn that technology must be assessed to determine the positive and negative effects, and how these have shaped today's global society. The key

component of the program is that students become knowledgeable about technology, and use hands-on lessons to apply and transfer this knowledge to common problems. The program consists of seven courses in Grades 6-12 that build on experiences provided in elementary school.

K-2nd Grades	Lessons integrated	
3rd-5th Grades	Lessons integrated	
6th Grade	Exploring Technology	9 weeks
7th Grade	Invention and Innovation	12-18 weeks
8th Grade	Technological Systems	18 weeks
9th Grade	Foundations of Technology	1 credit 36 weeks
10-12th Grades	Technological Issues	1 credit 36 weeks
	Impacts of Technology	1 credit 36 weeks
	Engineering Design	1 credit 36 weeks

Engineering By Design: Student-Oriented Program Description for Registration Booklets

Students in this program use hands-on lessons to learn the concepts and roles of engineering, design, invention, and innovation in creating technology systems that help make life easier and better. They learn to apply and transfer this knowledge to common everyday problems. Students learn how to assess technology, its impacts and resulting issues, and present the positive and negative consequences and how these have shaped today's global society. The program incorporates the applications of mathematics and science concepts and provides a strong background for students investigating careers in all career-focused academies.

K-2nd Grades	Lessons integrated	
3rd-5th Grades	Lessons integrated	
6th Grade	Exploring Technology	9 weeks
7th Grade	Invention and Innovation	12-18 weeks
8th Grade	Technological Systems	18 weeks
9th Grade	Foundations of Technology	1 credit 36 weeks
10-12th Grades	Technological Issues	1 credit 36 weeks
	Impacts of Technology	1 credit 36 weeks
	Engineering Design	1 credit 36 weeks

Course Descriptions

The following is course information and interrelationships to ensure that students in all grades, K-12, have the opportunity to develop technological literacy.

Elementary Integration	**Lessons Integrated in Curricula in Grades K-2**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades K-2
Overview	Introducing young children to the natural world is a significant part of the elementary curriculum. Grades K-2 provide a unique opportunity to introduce and refine the knowledge and skills for understanding the designed world that is equally important during the early years. Children are as fascinated with the world of technology as the natural world, maybe even more intrigued. The earliest interest in "how things work" and what makes their environment function are clearly present in the earliest stages of a child's development. Making sense of the "natural" and "designed world" is the essence of the earliest attempts to learn by children. For every venture into the designed world, there are limitations, requirements, and elements that guide the process. Designing is a challenging and rigorous process. To design something means to apply all available resources, including knowledge and skills about all subjects, to effect a scheme, solution, concept, or theory that offers a reasonable and effective resolution to a problem. In order to comprehend the attributes of design, students in Grades K-2 learn that: • Everyone can design solutions to a problem. • Designing is a creative process that turns ideas into actions.
Course Length	Integrated throughout the year
Connections to: Technological Issues	These concepts connect to the Grades 3-5 emphasis on the design process and requirements for design, providing the basis for the middle and high school studies on Technology, Innovation, Design, and Engineering.

Elementary Integration	**Lessons Integrated in Curricula in Grades 3-5**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 3-5
Course Overview	In Grades 3-5, students should learn that: • The design process is a purposeful method of planning practical solutions to problems and includes: creating ideas, putting ideas on paper, using words and sketches, building models, testing the design or idea, and evaluating the solution based on requirements. • Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design such as, but not limited to, size, cost, type of material, weight, color, etc. Children have experiences in design at the earliest stages of development. Ingenuity is a natural human trait. It needs to be nurtured, developed, and refined. To design solutions to specific problems is the application of ingenuity. Add to this ingenuity several resources, parameters for the design solution, and some guidance, and children begin to display an interest in and ability to understand the design process. To this end, they have the foundation for understanding technological development and innovation.
Course Length	Integrated throughout the year
Connections to: *Technological Issues*	These concepts connect to the middle school Program of Study, where students learn about technology, invention and innovation, and how the core concepts of technology and combined to create technology systems. This background provides the basis for more focused high school studies in Technology, Innovation, Design, and Engineering.

Name of Course	**Exploring Technology**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	6th Grade students (no prerequisite)
Course Overview	In *Exploring Technology*, students develop an understanding of the progression and scope of technology through exploratory experiences. In group and individual activities, students experience ways in which technological knowledge and processes contribute to effective designs and solutions to technological problems. Students participate in design activities to understand how criteria, constraints, and processes affect designs. Brainstorming, visualizing, modeling, constructing, testing, and refining designs provide firsthand opportunities for students to understand the uses and impacts of innovations. Students develop skills in communicating design information and reporting results. This course is a cornerstone for a middle school technology education program.
Course Length	9 weeks
Connections to: *Technological Issues*	*Exploring Technology* builds on K-5 experiences and develops a student's understanding of the scope of technology and the iterative nature of technological design and problem-solving processes. Likewise, students will be able to communicate their ideas verbally and visually, and document the development of their plans through visual representation, journals, and portfolios. Teaming, peer monitoring, and individual actions contribute to student achievements at this level. Similarly, *Exploring Technology* provides the foundation for future studies in the sequence. Students learn how technology, innovation, design, and engineering interrelate and are interdependent. This background provides the basis for more focused high school studies. Students learn how technology, innovation, design, and engineering interrelate and are interdependent.

Name of Course	**Invention and Innovation**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	7th Grade students (no prerequisite)
Course Overview	*Invention and Innovation* provides students with opportunities to apply the design process in the invention or innovation of a new product, process, or system. In this course, students will learn all about invention and innovation. They will have opportunities to study the history of inventions and innovations, including their impacts on society. They will learn about the core concepts of technology, and about the various approaches to solving problems, including engineering design and experimentation. Students will apply their creativity in the invention and innovation of new products, processes, or systems. Finally, students learn about how various inventions and innovations impact their lives. Students participate in engineering design activities to understand how criteria, constraints, and processes affect designs. Students are involved in activities and experiences where they learn about brainstorming, visualizing, modeling, constructing, testing, experimenting, and refining designs. Students also develop skills in researching for information, communicating design information, and reporting results.
Course Length	12-18 weeks recommended
Connections to: *Technological Issues*	*Invention and Innovation* builds on K-5 experiences as well as those in *Exploring Technology* and develops a student's understanding of the scope of technology and the iterative nature of technological design and problem-solving processes. Likewise, students participate in engineering design activities to understand how criteria, constraints, and processes affect designs. Students will be involved in activities and experiences where they learn about brainstorming, visualizing, modeling, constructing, testing, experimenting, and refining designs. Students will also develop skills in researching for information, communicating design information, and reporting results. *Invention and Innovation* provides the foundation for future studies in the sequence. Students learn how technology, innovation, design and engineering interrelate and are interdependent.

Name of Course	**Technological Systems**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	8th Grade students (no prerequisite)
Course Overview	This course is intended to teach students how technological systems work together to solve problems and capture opportunities. A system can be as small as two components working together (technical system/device level) or can contain millions of interacting devices (user system/network level). We often break down the macrosystems into less complicated microsystems in order to understand the entire system better. However, technology is becoming more integrated, and systems are becoming more and more dependent upon each other than ever before. Electronic systems are interacting with natural (i.e. bio) systems as humans use more and more monitoring devices for medical reasons. Electrical systems are interacting with mechanical and fluid power systems as manufacturing establishments become more and more automated. This course will give students a general background on the different types of systems but will concentrate more on the connections between these systems.
Course Length	12-18 weeks recommended
Connections to: *Technological Issues*	*Technological Systems* builds on K-5 experiences as well as those in *Exploring Technology* and *Invention and Innovation* to develop a student's understanding of the scope of technology and the iterative nature of technological design and problem-solving processes. Students participate in engineering design activities to understand how criteria, constraints, and processes affect designs. Students are involved in activities and experiences where they learn about brainstorming, visualizing, modeling, constructing, testing, experimenting, and refining designs. Students also develop skills in researching for information, communicating design information, and reporting results. As the suggested capstone middle school course, *Technological Systems* provides the foundation for future studies in a Technology Education sequence. Students learn how technology, innovation, design, and engineering interrelate and are interdependent.

Name of Course	**Foundations of Technology**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 10-12
Course Overview	*Foundations of Technology* prepares students to understand and apply technological concepts and processes that are the cornerstone for the high school technology program. Group and individual activities engage students in creating ideas, developing innovations, and engineering practical solutions. Technology content, resources, and laboratory/classroom activities apply student applications of science, mathematics, and other school subjects in authentic situations.
Course Length	36 weeks recommended
Connections to: *Technological Issues*	The *Foundations of Technology* course is one component of the overall technology education program designed to prepare students for the technological world by preparing them to assume the roles of informed voters, productive workers, and wise consumers. The *Foundations of Technology* course will focus on the development of knowledge and skills regarding the following aspects of technology: 1) its evolution, 2) systems, 3) core concepts, 4) design, and 5) utilization. The *Foundations of Technology* course is an introductory high school level learning experience that builds on student understanding gained in elementary and middle school courses. It capitalizes on the maturing adolescent's ability to understand technological concepts and analyze issues regarding the application of technology. The course will prepare students for more specialized technology courses at the high school level such as *Engineering Design*, *Impacts of Technology*, and *Technological Issues*.

Name of Course	**Impacts of Technology**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 10-12: *Foundations of Technology* recommended Advanced Technology Education
Course Overview	Students in *Impacts of Technology* learn that technology is a neutral topic that can have good or impacts on society. This technology assessment is a structured evaluation of the application of technology in an effort to avoid inappropriate or unwanted effects. Applying design and student imagination without considering the possible effects of new products or processes can lead to technological disasters, superfund sites, and unsafe products that could have been avoided in the initial design stages. Whether a new product, system, or process has an overall positive, neutral, or negative impact depends on the proper understanding of technology assessment. This aspect of *Impacts of Technology* gives students a head start on the road to technological literacy by focusing primarily on technology assessment and the impact on *technology design*.
Course Length	36 weeks recommended
Connections to: *Technological Issues*	The thrust of the *Impacts of Technology* course contributes to the development of each high school student's capacity to make responsible judgments about technology's development, control, and use. Critiquing appropriate technology and sustainable development are important. The structure of the course brings discussions of technological values so that students can reflect and develop their own ethical standards. Students are actively involved in the organized and integrated application of technological resources, engineering concepts, and scientific procedures. Through high school technology education experiences, students address the complexities of technology and issues that stem from designing, developing, using, and assessing technological systems. In developing a functional understanding of technology, students comprehend how human conditions, current affairs, and personal preferences drive technological design and problem solving. Actively engaged in making and developing, using, and managing technological systems, students better understand the role of systems in meeting specific purposes. Students are able to analyze and understand the behavior and operation of basic technological systems in different contexts. Students are able to extend their knowledge of systems to new and emerging applications by the time they graduate from high school.

Name of Course	**Engineering Design**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 10-12: *Foundations of Technology* recommended Advanced Technology Education
Course Overview	In *Engineering Design*, engineering scope, content, and professional practices are presented through practical applications. Students in engineering teams apply technology, science, and mathematics concepts and skills to solve engineering design problems and innovate designs. Students research, develop, test, and analyze engineering designs using criteria such as design effectiveness, public safety, human factors, and ethics. This course is the capstone experience for students who are interested in technology, innovation, design, and engineering.
Course Length	36 weeks recommended
Connections to: *Technological Issues*	*Engineering Design* contributes to the development of each high school student's capacity to make responsible judgments about technology's development, control, and use. Critiquing appropriate technology and sustainable development are important. The structure of the course brings discussions of technological values so that students can reflect and develop their own ethical standards. Students are actively involved in the organized and integrated application of technological resources, engineering concepts, and scientific procedures. Through high school technology education experiences, students address the complexities of technology and issues that stem from designing, developing, using, and assessing technological systems. In developing a functional understanding of technology, students comprehend how human conditions, current affairs, and personal preferences drive technological design and problem solving. Actively engaged in making and developing, using, and managing technological systems, students better understand the role of systems in meeting specific purposes. Students are able to analyze and understand the behavior and operation of basic technological systems in different contexts. Students are able to extend their knowledge of systems to new and emerging applications by the time they graduate from high school. As the capstone experience for the ***Engineering By Design Program***, *Engineering Design* provides students with the knowledge and skills to delve deeper into engineering at the post-secondary level.

Overview:
Technological Issues

Engineering By Design
A National Model for Standards-Based Programs

Technological Issues Overview of the Course

Name of Course	**Technological Issues**
Standards Addressed	See Responsibility Matrix for Technology, Mathematics, and Science in Appendix A
Intended Audience	Grades 10-12: *Foundations of Technology* recommended Advanced Technology Education
Course Overview	In *Technological Issues*, students learn that technology allows us to extend our ability to modify or change the natural world to meet our wants and needs. However, the resulting changes can be complicated and unpredictable. Solutions to a particular problem may cause other types of problems. Each potential technological solution creates certain issues, such as benefits, costs, risks and limitations. Not all impacts of technology are predictable or show up right away. However, the key issues of a technology should be studied and debated prior to the technology being introduced or eliminated. Alternatives should be explored—scientific and mathematical dimensions should be integrated into the decision. Technological issues are not solely technical in nature. Attitudes towards technology can be influenced by social, cultural, economical, political, and ecological concerns. The decision to introduce or eliminate a technology will affect different people, and vary depending on the timing. Issues can create some heated debates, which require that both sides of the debate acquire detailed information and ask the right questions. Students learn that, by studying technological issues, there may not be a solution that everyone agrees upon, nor may everyone benefit or receive the cost in the same way. The study of technological issues will not give students the correct answers, but will allow them to develop skills in asking critical questions and understanding alternative viewpoints and their origins, and will give them the confidence to be involved in deciding which technologies to develop, which to use, and how to use them. *Technological Issues* allows students to investigate critical historical and emerging issues affecting the creation, development, use, and control of technology. They will use case studies, simulations, research, design, problem solving, and group discussions and presentations to address complex issues and propose alternative solutions to technological developments. Local, regional, and global governmental, social, and economic policies concerning technology are also studied. The course will focus on the development of knowledge and skills regarding the following aspects of technological issues: 1) recognition, 2) sources, 3) examining, 4) addressing, and 5) predicting.
Course Length	36 weeks recommended
Connections to Engineering By Design Program Sequence	*Technological Issues* contributes to the development of each high school student's capacity to make responsible judgments about technology's development, control, and use. Critiquing appropriate technology and sustainable development are important. The structure of the course brings discussions of technological values so that students can reflect and develop their own ethical standards. Students are actively involved in the organized and integrated application of technological resources, engineering concepts, and scientific procedures. Students address the complexities of technology and issues that stem from designing, developing, using, and assessing technological systems. In developing a functional understanding of technology, students comprehend how human conditions, current affairs, and personal preferences drive technological design and problem solving. Actively engaged in making and developing, using, and managing technological systems, students better understand the role of systems in meeting specific purposes. Students are able to analyze and understand the behavior and operation of basic technological systems in different contexts. Students are able to extend their knowledge of systems to new and emerging applications by the time they graduate from high school.

Course Goals and Objectives

At the completion of this course, students will know and understand:

1. Technological issues can have various effects on individuals, groups or societies that may vary with time and place.
2. Society and culture may affect the development of technology and, conversely, technological development may affect social and cultural changes.
3. Not all human problems are technological, and not every problem can be solved with technology.
4. Technology is related to other disciplines, may be affected by them or may affect them, and requires other disciplines for a complete technological analysis of issues.
5. Sources of technological issues include the technology itself, how and where it is transferred, and how it interacts with the environment.
6. Human needs, ethics, social trends, and technological trade-offs must be considered during the design of technology to minimize negative issues.
7. Policies, practices, and protections are necessary to limit technological issues.
8. A variety of tools and processes are available to predict outcomes of technological designs or problem solutions in advance.

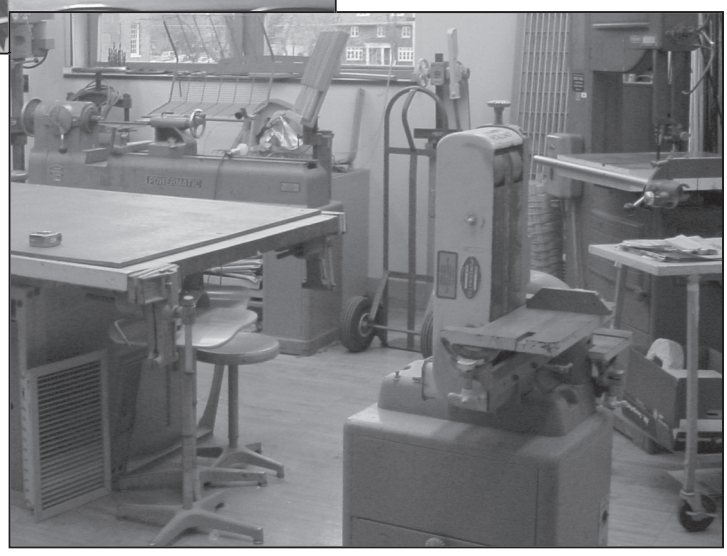
At the completion of this course, students will be able to:

1. Recognize various types of social and technological issues that arise from the implementation of technology.
2. Use a multidisciplinary approach in studying technological issues.
3. Apply lessons from historical studies of technological issues to present and future applications of technology.
4. Evaluate the issues related to technology transfer within and between cultures.
5. Identify constraints and limitations to the design and demand of technology.
6. Recognize various points of view of ethics, trade-offs, economics, and the environment when examining technological issues.
7. Examine various practices, policies, and protections that affect technological issues.
8. Apply design and problem-solving skills to technological problems that result in a solution that minimizes the issues.
9. Research, collect, and synthesize data, and draw conclusions on the effects of technology on individuals, groups, or society.
10. Use a variety of assessment and futurology tools to extrapolate future impacts from technological issues.

Course Assessment

Performance Tasks and Projects (consider scope and sequence)
1. Open-ended questioning
2. Discussions/Interviews
3. Research and Experimentations
4. Topic Investigations
5. Presentations, with self and peer assessments
6. Evaluation of a prototype
7. Development of a prototype of a new or refined product
8. Portfolios/Journals/Design Briefs

Written Assessments (student self-assessment, concept mappings, quizzes, tests, and any other written assessment planned for the course):
1. Multiple choice tests
2. Completion tests
3. Concept mapping
4. Essay tests
5. Scenarios/Case studies



Typical facilities for Technological Issues should include a design area (above) and a prototyping area (right).

Unit No.	Unit Title	Big Idea	Below Target	At Target	Above Target
1	Recognizing Technological Issues	The selection, application, and consequences of all technology, create various types of issues that may affect individuals, groups, and/or society as a whole.	The student has an inadequate or narrow grasp of the big idea: unsatisfactorily explains how historical examples of technological issues help us better understand current and future issues as they arise; inadequately recognizes that addressing technological issues requires a multidisciplinary approach; unsatisfactorily explains that technology and society affect each other, inadequately explains that all technologies have alternatives, each with their own benefits and risks.	The student shows evidence of understanding the big idea:explains how historical examples of technological issues help us better understand current and future issues as they arise; recognizes that addressing technological issues requires a multidisciplinary approach; describes examples of how technology and society affect each other;recognizes technology alternatives, including their benefits and risks	The student thoroughly understands the big idea:provides numerous examples of how historical technological issues help us better understand current and future issues as they arise; thoroughly recognizes that addressing technological issues requires a multidisciplinary approach; analyzes and describes how technology and society affect each other; proficiently describes technology alternatives, including examples of their benefits and risks.
2	Sources of Technological Issues	Technological issues can result from the technology itself, how or where it is transferred, or how it interacts with the limitations of the environment or ecosystem.	The student has an inadequate or narrow grasp of the big idea: inadequately explains how growth of human population and economic systems create technological issues; unsatisfactorily explains how transferring technology can create cultural as well as technological issues; inadequately explains how engineering design often creates unforeseen failures;fails to identify that the Earth has limited energy and material resources, as well as a limited ability to recycle wastes.	The student shows evidence of understand the big idea: explains that growth of human population and economic systems can create technological issues; provides examples of how transferring technology can create cultural as well as technological issues; identifies examples of engineering design failures; recognizes that the Earth has limited energy and material resources, as well as a limited ability to recycle wastes.	The student thoroughly understands the big idea:thoroughly understands how growth of human population and economic systems create technological issues; effectively explains how transferring technology can create cultural as well as technological issues;effectively recognizes that engineering design often creates unforeseen failures;clearly articulates how the Earth has limited energy and material resources, as well as a limited ability to recycle wastes.

Unit No.	Unit Title	Big Idea	Below Target	At Target	Above Target
3	Examining Technological Issues	Examining why and what humans design, the constraints and limitations, and how the designs interact with society and the environment, helps us create designs and solve problems with fewer technological issues.	The student has an inadequate or narrow grasp of the big idea: fails to recognize that design should include safety and quality of life; inadequately explains that design criteria and constraints should use ergonomic principles; unsatisfactorily explains how ethics and product liability are important to reduce technological issues; shows little understanding of why environmental assessments and monitoring should be done in advance to limit technological issues.	The student shows evidence of understanding the big idea: provides examples of design that include safety and quality of life; adequately explains that design criteria and constraints should use ergonomic principles; explains how ethics and product liability are important to reduce technological issues; justifies why environmental assessments and monitoring should be done in advance to limit technological issues.	The student thoroughly understands the big idea: clearly articulates how design should include safety and quality of life; thoroughly explains how design criteria and constraints should use ergonomic principles; analyzes how ethics and product liability are important to reduce technological issues; effectively explains why environmental assessments and monitoring should be done in advance to limit technological issues.
4	Addressing Technological Issues	Developing solutions to address human needs or wants, requires certain practices, policies, and protections to minimize technological issues.	The student has an inadequate or narrow grasp of the big idea: unsatisfactorily explains how appropriate technology is a design methodology that incorporates the technology, the user, and the location; inaccurately recognizes how careful selection of materials and processes, including recycling and green products, limits technological issues; fails to understand how policies and regulations can govern designs and problem solutions to limit technological issues; inadequately explains how acquiring, applying, and protecting technical knowledge reduces technological issues.	The student shows evidence of understanding the big idea: provides examples of how appropriate technology is a design methodology that incorporates the technology, the user, and the location; explains how the careful selection of materials and processes, including recycling and green products, limits technological issues; identifies how policies and regulations can govern designs and problem solutions to limit technological issues; explains how acquiring, applying, and protecting technical knowledge reduces technological issues.	The student thoroughly understands the big idea:thoroughly explains how appropriate technology is a design methodology that incorporates the technology, the user, and the location; clearly articulates how the careful selection of materials and processes, including recycling and green products, limits technological issues; analyzes how policies and regulations can govern designs and problem solutions to limit technological issues; proficiently explains how acquiring, applying, and protecting technical knowledge reduces technological issues.

Unit No.	Unit Title	Big Idea	Below Target	At Target	Above Target
5	Predicting Technological Issues	A variety of tools and processes are available to predict outcomes of designs or problem solutions in advance, thus limiting negative technological issues.	The student has an inadequate or narrow grasp of the big idea: unsatisfactorily explains how design analysis tools can be used to select a design or solution with the least amount of technological issues; inadequately explains how modeling, gaming, and simulations can be used to examine systems before they are fully developed; cannot explain how technology assessment tools are used to research possible negative impacts prior to the selection and use of a variety of technologies; inadequately investigates how forecasting and other futurology techniques can be used to minimize possible technological issues in advance.	The student shows evidence of understanding the big idea: explains how design analysis tools can be used to select a design or solution with the least amount of technological issues; provides examples of how modeling, gaming, and simulations can be used to examine systems before they are fully developed; explains how technology assessment tools are used to research possible negative impacts prior to the selection and use of a variety of technologies; identifies how forecasting and other futurology techniques can be used to minimize possible technological issues in advance.	The student thoroughly understands the big idea:thoroughly explains how design analysis tools can be used to select a design or solution with the least amount of technological issues; clearly articulates how modeling, gaming and simulations can be used to examine systems before they are fully developed; proficiently explains how technology assessment tools are used to research possible negative impacts prior to the selection and use of a variety of technologies; effectively explains how forecasting and other futurology techniques can be used to minimize possible technological issues in advance.

Course Content Outline

I. Recognition – The selection, application, and consequences of all technology create various types of issues, which may affect individuals, groups and/or society as a whole.
   A. Historical examples of technological issues help us better understand current and future issues as they arise.
   B. Recognizing and addressing technological issues requires a multidisciplinary approach.
   C. Technology and society affect each other.
   D. All technologies have alternatives, each with its own benefits and risks.

II. Sources – Technological issues can result from the technology itself, how or where it is transferred, or how it interacts with the limitations of the environment or ecosystem.
   A. Growth of human population and economic systems creates technological issues.
   B. Transferring technology can create cultural as well as technological issues.
   C. Engineering design often creates unforeseen failures.
   D. The Earth has limited energy and material resources as well as a limited ability to recycle wastes.

III. Examining – Examining why and what humans design, the constraints and limitations, and how the designs interact with society and the environment, helps us create designs and solve problems with fewer technological issues.
   A. Needs assessment for design includes safety and quality of life.
   B. Design criteria and constraints should use ergonomic principles.
   C. Ethics and product liability are important to reduce technological issues.
   D. Environmental assessments and monitoring should be done in advance to limit technological issues.

IV. Addressing – Developing solutions to address human needs or wants requires certain practices, policies, and protections to minimize technological issues.
   A. Appropriate technology is a design methodology that incorporates the technology, the user, and the location.
   B. Careful selection of materials and processes, including recycling and green products, limits technological issues.
   C. Policies and regulations can govern designs and problem solutions to limit technological issues.
   D. Acquiring, applying, and protecting technical knowledge reduces technological issues.

V. Predicting – A variety of tools and processes are available to predict outcomes of designs or problem solutions in advance, thus limiting negative technological issues.
   A. Design analysis tools can be used to select a design or solution with the least amount of technological issues.
   B. Modeling, gaming, and simulations can be used to examine systems before they are fully developed.
   C. Technology assessment tools are used to research possible negative impacts prior to the selection and use of a variety of technologies.
   D. Forecasting and other futurology techniques can be used to minimize possible technological issues in advance.

Course Lessons and Corresponding Assignments (Activities)

Lesson Number and Title	Corresponding Assignment Number	Hours of Instruction
Course Introduction & Lab Safety		2
Unit I - Lesson One: Introduction to Technological Issues Using a Historical Case Study	Lesson 1-1	4
Unit I - Lesson Two: Relating Technological Issues to Other Subject Areas	Lesson 1-2	4
Unit I - Lesson Three: Examining a Technology and its Adoption	Lesson 1-3	4
Unit I - Lesson Four: Technology Alternatives: Benefits and Risks	Lesson 1-4	4
Unit II - Lesson One: Examining Exponential Growth	Lesson 2-1	4
Unit II - Lesson Two: Evaluating Technology Transfer	Lesson 2-2	6
Unit II - Lesson Three: Issues from Engineering Design Failures	Lesson 2-3	4
Unit II - Lesson Four: Examining Earth's Limited Resources	Lesson 2-4	6
Unit III - Lesson One: Design and Technology for Quality of Life	Lesson 3-1	6
Unit III - Lesson Two: Criteria for Safe and Ergonomic Design	Lesson 3-2	4
Unit III - Lesson Three: Design Ethics and Product Liability	Lesson 3-3	4
Unit III - Lesson Four: Modeling Monitoring Technology	Lesson 3-4	6
Unit IV - Lesson One: Appropriate Technology Design	Lesson 4-1	12
Unit IV - Lesson Two: Model City Design Based on Recycling and Green Products	Lesson 4-2	12
Unit IV - Lesson Three: Debating Current Technologies and Their Issues	Lesson 4-3	6
Unit IV - Lesson Four: Protecting Technology	Lesson 4-4	6
Unit V - Lesson One: Weighing and Prioritizing Design Trade-Offs	Lesson 5-1	4
Unit V - Lesson Two: Using Models, Simulations, and Games	Lesson 5-2	6
Unit V - Lesson Three: Applying Technology Assessment Tools	Lesson 5-3	4
Unit V - Lesson Four: Applying Forecasting/Futurology Tools	Lesson 5-4	6
Review, Quizzes, Tests		4
School Functions/Make-up Time		2
Total		120 hours*

*120 hours equates to 180 days (full year course) at 40 minutes per period

Unit I
Recognizing Technological Issues

Engineering By Design
A National Model for Standards-Based Programs

Unit 1: Recognizing Technological Issues

STL Standards

- Students will develop an understanding of the relationships among technologies and the connections between technology and other fields. (3)
- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop an understanding of the effects of technology on the environment. (5)
- Students will develop an understanding of the role of society in the development and use of technology. (6)
- Students will develop an understanding of the influence of technology on history. (7)
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation and problem solving. (10)
- Students will develop the abilities to use and maintain technological products and systems. (12)

STL Benchmarks

- Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. (3H)
- Technological progress promotes the advancement of science and mathematics. (3J)
- Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious. (4H)
- Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment. (5L)
- The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. (6I)
- Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. (7I)
- Not all problems are technological, and not every problem can be solved using technology. (10K)
- Many technological problems require a multidisciplinary approach. (10L)
- (Students should be able to) Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. (12P)

Mathematics Standards

14H Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population

22C Use representations to model and interpret physical, social, and mathematical phenomena

Science Standards

3P Progress in science and invention depends heavily on what else is happening in society, and history often depends on scientific and technological developments.

8J In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.

8K The value of any given technology may be different for different groups of people and at different points in time.

8M Risk analysis is used to minimize the likelihood of unwanted side effects of a new technology. The public perception of risk may depend, however, on psychological factors as well as scientific ones.

9Q Social and economic forces strongly influence which technologies will be developed and used. Which will prevail is affected by many factors, such as personal values, consumer acceptance, patent laws, the availability of risk capital, the federal budget, local and national regulations, media attention, economic competition, and tax incentives.

9U Human inventiveness has brought new risks as well as improvements to human existence.

Big Idea:
The selection, application, and consequences of all technology create various types of issues, which may affect individuals, groups and/or society as a whole.

Unit 1 Objectives

At the completion of this unit, students will be able to:

- Recognize various types of issues that arise from the implementation of technology.
- Examine technological issues using a multidisciplinary approach.
- Examine the effects of society on the rate and nature of technology adoption.
- Evaluate technology alternatives in terms of benefits and risks.

Assessment

Assessment for each lesson includes a quiz, and rubrics will be used for group work and/or parts of the research, analysis and presentation.

Teacher Preparation

Teacher preparation for this unit should include:

- Gather references, or make available examples of historical changes and technological innovations and inventions. As students discover good references, Web sites, films/documentaries, local historical sites, etc., develop a database.
- Research historical events to examine their technological and social interactions. Develop a list of potential topics for the students.
- Discuss with other teachers what students are studying in their classes, including history, economics, social studies, science, mathematics, and other technology classes, and how those concepts are related to technological issues.
- Gather examples of technological and/or social issues that are current from news articles or media presentations.
- Review teaching methodologies used in lessons one through four.
- Make copies of the assignments (one page, double sided if need be) and the worksheets (one page, double sided if need be) for each student or group.

Unit 1 – Lesson 1

Introduction to Technological Issues Using an Historical Case Study

Lesson Duration: Four (4) hours.

STL Standards

- Students will develop an understanding of the role of society in the development and use of technology. (6)
- Students will develop an understanding of the influence of technology on history. (7)
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation and problem solving. (10)
- Students will develop the abilities to use and maintain technological products and systems. (12)

STL Benchmarks

- The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. (6I)
- Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. (7I)
- Not all problems are technological, and not every problem can be solved using technology. (10K)
- Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. (12P)

Learning Objectives

Upon completion of this lesson, students will be able to:

1. Recognize various types of issues that arise from the implementation of technology.
2. Classify the influences of technological issues into categories such as social, economic, technological, environmental, etc.
3. Examine historical events using a multitude of viewpoints.
4. Research and record data through the use of tables, charts, or data bases.
5. Assess major significant issues and their consequences based on historical records.
6. Use representations to model and interpret physical and social phenomena.
7. Explain how progress in science and invention depends heavily on what else is happening in society.
8. Demonstrate how social and economic forces strongly influence which technologies will be developed and used.
9. Contribute positively to a group effort.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.

1-1A.
1-1B.
1-1C.
1-1D.
1-1E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did their part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on them.	Went beyond what was expected of them.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Research/Analysis

Category	Below Target	At Target	Above Target
Variety of sources	Use very little or varied sources.	Used multiple sources with multiple perspectives.	Used many sources with a variety of viewpoints.
Documentation	Little or inadequate documentation.	All sources documented and done so properly.	Documentation was well developed and referenced.
Reflection	Analysis showed little effort.	Analysis was thorough and well thought out.	Analysis was exceptionally well thought out—showed keen insight.

Assessment Instrument – Presentation

Category	Below Target	At Target	Above Target
Organization	Presentation is not well organized and is hard to follow.	Presentation is well organized and easy to follow.	Presentation is exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation is creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.
Feedback	Audience did not participate in the presentation.	Audience was attentive to the presentation, participated when asked.	Audience was extremely interested and asked many questions.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group work	As per above			
Research/ Analysis	As per above			
Presentation				

Resource Materials

- Print-Based Sources
  - *Social Issues in Technology: A Format for Investigation* (1986) P. Alcorn
  - *Technology in Western Civilization* (1967) M. Kranzberg & C. Pursell
  - *Science & Technology in World History* (1999) James McClellan III
- Audiovisual Materials
  - *Connections* – James Burke
  - *The Day the Universe Changed* – James Burke
  - *Industrial Revolution* (libraryvideo.com)
- Internet Sites
  - www.loc.gov/rr/scitech/tracer-bullets/historyoftechtb.html – Library of Congress site for History of Science and Technology
  - www2.lib.udel.edu/subj/hsci/internet.htm – University of Delaware library starting point for history research

Purpose of Lesson

To introduce the students to the types of issues that arise in the adoption of technology, categorize them, and reflect on how they have influenced people.

Required Knowledge and/or Skills

Students should have the ability to research a variety of mediums (print, Web, audio/visual), graphically represent the information, and analyze its content. The use of materials and information from other classes (disciplines) should be encouraged.

Lesson 1-1:

Engagement

1. The teacher may begin by discussing different periods of human history, drawing on information that students have received in other classes. How did people adapt to their environments in each of those periods? How did they feed themselves, prepare goods such as clothing and tools, transport items, communicate, etc.?
2. Students should discuss how people addressed their basic human needs (shelter, food, etc.) and how people organized their social structures during those periods of history (government, religion, commerce, social status, etc.).
3. The teacher can introduce examples of technologies that were developed during various periods of history. Using specific examples, students can discuss how the technology influenced social structures and how the structures influenced the introduction of the technology. The automobile is a good example to start with for class participation. Consider life prior to the introduction of the automobile. How did we transport people and products? How far away could we realistically socialize? How did we deal with the pollution from our current transportation (horses)? Where did we purchase most of our goods? How were products manufactured at that time? Why was local government so important at the time? And finally, how did this all change after the automobile arrived?

Exploration

1. Working in small groups, students will select an historical technology and research its development (e.g. printing press, radio, assembly line, steam power, glass production, electricity, microscope, etc.).
2. The student groups will research a variety of sources and gather information about issues surrounding the development of the technology. These can be organized into categories such as

technological, economical, political, social, ethical/cultural, environmental, and others.
3. Students will organize their collected information into a table, chart, or other database format.

Explanation

1. Student groups will select a technology and briefly explain to the class some background information on the topic and why they selected it.
2. The teacher may lead a discussion on types of issues and some obvious examples from history. For example, throughout our history, the introduction of new technology has created social issues. Often, a technological solution to one problem created additional issues that required attention. For example, the industrial revolution changed how we work, moving large numbers of people away from farms or small cottage industries into large companies centered in cities or near energy sources. In many cases, new technology has created social issues. People who worked in factories in the early industrial revolution became alienated with their jobs. Additionally, social issues have sparked the need for new technology. Finally, some issues we have encountered may not have had technological solutions. In order for us to face current and future issues, it is important for us to examine how technology and society are closely related.
3. The teacher will work with the groups to help them identify issues and show them how to place the issues in specific categories. The student worksheet will help the groups organize and collect their information.
4. The teacher will work with the groups to help them determine consequences of the issues for their selected technology.

Extension

1. Students will collect and record references for their data, using a variety of sources to get various perspectives and issues related to the development of their selected technology.
2. Students will analyze the research material, and determine which information should be used in their presentation.
3. Students will develop a visual table, chart, or other database that includes the issues categories, the issues that occurred at that period of time, and the consequences or changes that resulted in that category (e.g. the development of construction techniques for medieval churches based on cultural needs to design taller buildings).
4. Students will make a brief (3-5 minute) presentation to the class, showing their chart/table and describing the most important aspects of the issues related to their technology.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, research/analysis, and presentation.

Additional Extension Activities

1. Students may research an historical technology that was important to their local community or region (e.g. canal or railroad development).
2. Student presentation models may be displayed in a local library or museum for a period of time.
3. Students may make their presentations to other classes, local or regional community or social groups, in or out of the school.
4. Class work could be collated into a booklet, CD, or other format for dissemination, or used to collect donations for the technology program.

Laboratory-Classroom Preparation

Students should have access to information gathering and research, room for small-group and whole-class discussion, and media and equipment for graphic production and presentations.

Tools/Materials/Equipment

Research materials and Web access
Computers/software
Printers
Poster/sign maker
Media projector

Laboratory-Classroom Safety and Conduct

- Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.
- Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.

Assignment – Lesson 1-1
Introduction to Technological Issues
Using an Historical Case Study

Selecting an Event

Select an historical event that includes a technological innovation, invention, or new application of an older technology. Look for an event that has had significant impact on one or more social institutions. You may need to review several references to find the social connections. Be sure to record the publishing information for each reference you use. A few technology examples are provided here, and are categorized:

Information: printing press, radio, television, technology and music, photography, computer, cell phone
Manufacturing: Industrial Revolution (Europe), Industrial Revolution (America), assembly line, interchangeability of parts, robotics
Transportation: sail power, steam power, waterways and trade, railroads, flight
Construction: history of glass, housing, dam building, steel frames, electricity, architecture
Biotechnology: artificial insemination, horticulture, genetic engineering, cross pollination, medical technology, hydroponics
Technology and Design: plow, microscope, telescope, plastics and new materials, refrigeration, nuclear power, laser

Examining the Event

As you research your event, record the issues and problems encountered as the new technology was introduced. Examine how things were before and after the introduction of the technology. What changed, and how significant were the changes? You can use the chart on the worksheet as you research, and later use it for your analysis. The worksheet chart can be reproduced as needed. Be sure to get all sides of each issue as you research, and try to get the perspective of all the people involved.

Analysis

As you research, try to complete as much of the table as you can. This may require using a variety of sources and views from different people, such as technologists, politicians, economists, historians, scientists, and others. When you have exhausted your research, it is time to reflect upon your data and develop some analysis. You should be able to describe the significant issues, problems, and solutions encountered during the introduction of your technological event. You should also describe the changes brought about by the technology. You may add your own conclusions (opinions) at the end, based on your findings.

Presentation

You may present the analysis in a variety of methods (check with your teacher). The presentation should focus on your analysis. Be sure to include your references, as another student may want to do some further research on your event.

Assignment Worksheet – Lesson 1-1

Student Name(s): **Event:**

Date:

Research (copy as needed)

Issues Categories	Issues	Consequences or Changes
Technological		
Economic		
Political		
Social		
Ethical/Cultural		
Environmental		
Individual Freedom, Work & Leisure		
Other: _____		

Bibliography (list all sources used)

Analysis Notes

Ideas for Presentation

Unit 1 – Lesson 2

Relating Technological Issues to Other Subject Areas

Lesson Duration: Four (4) hours.

STL Standards

- Students will develop an understanding of the relationships among technologies and the connections between technology and other fields. (3)
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation and problem solving. (10)
- Students will develop the abilities to use and maintain technological products and systems. (12)

STL Benchmarks

- Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. (3H)
- Technological progress promotes the advancement of science and mathematics. (3J)
- Not all problems are technological, and not every problem can be solved using technology. (10K)
- Many technological problems require a multidisciplinary approach. (10L)
- Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. (12P)

Learning Objectives

Upon completion of this lesson, students will be able to:

1. Examine technological issues using a multidisciplinary approach.
2. Utilize perspectives gained from other course work to analyze a technology.
3. Recognize how knowledge from other disciplines may affect the selection, use, or impacts of a technology.
4. Construct a model of how science, mathematics, and other disciplines may interact with technology.
5. Use representations to model and interpret physical, social, and mathematical phenomena.
6. Contribute positively to a group effort.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.

1-2A.
1-2B.
1-2C.
1-2D.
1-2E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did their part of the work. Often offered useful ideas	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on them.	Went beyond what was expected of them.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of other. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Research/Organization

Category	Below Target	At Target	Above Target
Variety of Sources	Use very little or varied sources.	Used multiple sources with multiple perspectives	Used many sources with a variety of viewpoints
Levels	Has limited second- and third-level concepts from other disciplines.	Has a good amount on first-, second-, and third-level concepts.	Has many concepts that go into multiple levels.
Model Construction	Map is constructed poorly and hard to follow.	Map is well constructed and easily followed.	Map is creatively done and is very easy to follow and understand.

Assessment Instrument – Presentation

Category	Below Target	At Target	Above Target
Organization	Presentation is not well organized and is hard to follow.	Presentation is well organized and easy to follow.	Presentation is exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation was creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.
Feedback	Audience did not participate in the presentation.	Audience was attentive to the presentation and participated when asked.	Audience was extremely interested and asked many questions.

Assessment Totals:

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group work	As per above			
Research/ Analysis	As per above			
Presentation				

Resource Materials

- Print-Based Sources
  Textbooks and resources from other classes.
- Audiovisual Materials
  Sample concept maps from previous classes
  The Way Things Work (libraryvideo.com)
- Internet Sites
  Use the phrase "concept mapping" on a Web search engine to look for free online concept mapping programs.

Purpose of Lesson

To help students see the connections of technology to other subject area disciplines and how they may affect the selection and use of technology.

Required Knowledge and/or Skills

Students will need to reflect on knowledge, skills, and attitudes gained from their other courses. They should be able to use or develop the skill to use concept mapping software—or other graphic techniques—to model the same information.

Lesson 1-2:

Engagement

1. The teacher should provide examples of technology and have students reflect upon the content involved with that technology from other discipline areas, including mathematics, science, arts, social sciences, etc. Examples may come from the previous lesson.
2. The students should examine examples of how the development and use of the technology was aided by the other disciplines, as well has how the technology helped the advancement of the other areas. For example, the scientific urge to study the stars and planets helped people develop the telescope and, as the telescope was refined, additional scientific discoveries were made.

Exploration

1. Working in small groups, students will select a technology that has had a significant impact. They should brainstorm and/or research as many connections to other disciplines as they can. They can include other disciplines that affected the technology, or other disciplines that were affected by the technology. Examples of technological problems are suggested on the assignment sheet.
2. Students may want to revisit this assignment during their other classes to examine concepts from the other disciplines. They should gather specific concepts (e.g. identify planetary motion as opposed to the larger term of astronomy).
3. Students should identify primary, as well as secondary and tertiary, types of concepts as they do their research. For example, a construction technology link to geometry may reveal the following links: triangles, right triangles, Pythagorean theorem. Each successive link provides more specific information.
4. Once students have exhausted their research, they will need to begin to organize their concepts as they branch away from the main technology topic. Links should be identified from the technology to the primary links, then the secondary, etc.

Explanation

1. The teacher may have the students briefly explain the concepts they have discovered early in the activity. This may spark ideas in other groups on topics they had not yet considered.
2. The teacher may suggest additional topics to each group as they move about the small groups.
3. The teacher may want to show the students a completed concept map to provide them with ideas on how to organize their information. They can also demonstrate the use of concept mapping software, or other database applications.
4. Once the students have developed their model, they should script their presentation and possibly practice their delivery.

Extension

1. Students will organize their information and develop a model of presentation (concept map, database, or other graphic presentation). The student worksheet will help the groups organize their information and prepare for their presentation.
2. The students may want to brainstorm several organizational strategies before selecting the final presentation.
3. Students may present (3-5 minutes) their model to the class.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, research/organization, and presentation.

Additional Extension Activities

1. Students may revisit this assignment throughout the year and add as many concepts as possible from all their subject areas for that school year. The final project can be then compared to the original, noting the new connections they have been able to make.
2. Student presentations can be displayed in the school or local community center for a period of time.
3. A database of concept maps can be archived by the teacher in a technology classroom data base for future reference.

Laboratory-Classroom Preparation

Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations.

Tools/Materials/Equipment

Computers/software
Printers
Poster/sign maker and other graphic tools
Media projector

Laboratory-Classroom Safety and Conduct

Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.

Assignment – Lesson 1-2
Relating Technological Issues to Other Subject Areas

Selecting a Technology

Select an historical or current technology that has had (or is having) a social interaction. Select a technology that allows you to examine the links to various other disciplines, including science, mathematics, the arts, the social sciences, etc. You may need to review several references and reflect in your other classes to find important connections. A few technology examples are provided here and are categorized:

Information: printing press, radio, television, camera, computer, cell phone
Manufacturing: plastic products, manufactured house, ordering products online, automation
Transportation: steam engine, power steering, bicycle, electric vehicles, hybrid vehicles
Construction: plywood, balloon framing, steel beams, owner-builder housing, concrete
Biotechnology: genetically altered foods, radiated foods, new drugs, artificial limbs or organs
Technology and Design: plow, plastics and new materials, refrigeration, nuclear power, laser

Researching the Issues

Based on the types of information you uncovered in Lesson 1, identify related concepts from a variety of disciplines that relate to your topic. Remember, you are not identifying solutions, only broad concepts and their sub-concepts. After developing broad concepts, research and brainstorm sub-concepts that support the broad ones. You should not worry whether an issue is broad-based or a sub-concept as you brainstorm; these items can be reorganized later. Your teacher may want to do this as a class on one technology prior to you researching your individual technologies. You can use the chart on the worksheet as you research, and later use it to prepare your concept map. The worksheet chart can be reproduced as needed.

Organizing the Issues

Once you or your team has completely exhausted all possible concepts, you will need to organize them. Reflectively look at your list and first identify a handful of broad concepts. Next, identify the sub-concepts and which broad concept they are related to. You can organize these as lists or put them in outline format. It is often helpful to put away your list for a certain period and then come back to it with a fresh look to see if it makes sense. Additionally, you may want to show someone outside of your group to get an alternative look at the list. You can reorganize it as needed.

Developing the Concept Map

Several computer programs are available to develop your concept map. If they are not available, creatively develop your concept map on heavy paper or poster board. You may want to lay it out in light pencil first so that everything fits together and it looks proportional.

Assignment Worksheet – Lesson 1-2

Student Name(s): **Technology:**

Date:

Research (copy as needed)

Do not worry about where to place topics, they can be reorganized later.

Type of Issue	Broad Concepts	Sub-Concepts	Sub-Sub-Concepts
Technology			
Science			
Mathematics			
Social Studies			
Arts			
Social Sciences			
Other _____			

Bibliography (list all sources used)

Bibliography (continued)

Outline or List of Broad/Sub-Concepts (rework as needed)

Sketch of Concept Map (use additional paper as needed)

Unit 1 – Lesson 3

Examining a Technology and its Adoption

Lesson Duration: Four (4) hours.

STL Standards

- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop an understanding of the role of society in the development and use of technology. (6)
- Students will develop the abilities to use and maintain technological products and systems. (12)

STL Benchmarks

- Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious. (4H)
- The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. (6I)
- Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. (12P)

Learning Objectives

Upon completion of this lesson, students will be able to:

1. Describe factors that affect the rate of adoption of a technology.
2. Recognize different types of adopters and when they get involved with a new technology.
3. Identify problems, technological and/or social, that affect technology development.
4. Uncover spin-off applications from the development of a technology.
5. Recognize that progress in science and invention depends heavily on what else is happening in society.
6. Determine how human inventiveness has brought new risks as well as improvements to human existence.
7. Develop a written report, including an introduction, a series of connected thoughts, and a solid conclusion.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (see Appendix E for pre/post test)
Directions: Select the response that best answers the question.

1-3A.
1-3B.
1-3C.
1-3D.
1-3E.

Assessment Instrument – Research

Category	Below Target	At Target	Above Target
Variety of Sources	Used very little or varied sources.	Used multiple sources with multiple perspectives.	Used many sources with a variety of view points.
Documentation	Little or inadequate documentation.	All sources documented and done so properly.	Documentation was well developed and referenced.
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.

Assessment Instrument – Report

Category	Below Target	At Target	Above Target
Organization	Report is not well organized and is hard to follow.	Report is well organized and easy to follow.	Report is exceptionally well organized and flows very well.
Components	Components missing, little or no documentation.	Most components were included and easy to find.	All components well fulfilled and additional ones met.
Grammar/ Spelling	Many spelling errors and grammatical mistakes.	Very few spelling error or grammatical mistakes.	No spelling errors and exceptional grammar.

Assessment Instrument – Presentation

Category	Below Target	At Target	Above Target
Organization	Presentation is not well organized and is hard to follow.	Presentation is well organized and easy to follow.	Presentation is exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation was creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation
Feedback	Audience did not participate in the presentation.	Audience was attentive to the presentation and participated when asked.	Audience was extremely interested and asked many questions.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Research	As per above			
Rrport	As per above			
Presentation	As per above			

Resource Materials

- Print-Based Sources
  Diffusions of Innovation (1995) Everett Rodgers 4th ed.
  Technology, Change, and Society (1978) E. Pytlik (et.al.)
- Audiovisual Materials
  Connections – James Burke
  The Day the Universe Changed – James Burke
  On the Line – Story of Henry Ford (shop.wgbh.org)
- Internet Sites
  http://tlc.nlm.nih.gov/resources/publications/sourcebook/adoptiondiffusion.html
  information on adoption and diffusion from *The Learning Channel*

Purpose of Lesson

To introduce students to the factors that affect the rate of adoption of a technology, who is involved, and how the technology can cause other developments and spin-offs.

Required Knowledge and/or Skills

Students should have the ability to research a variety of mediums, develop a structured view of a process, and be able to communicate the process through a well structured and edited position paper.

Lesson 1-3:

Engagement

1. The teacher should begin by presenting an example of technology and the details of how it was developed. Discussion should center on questions such as: How fast was it accepted? Was it rejected at first? Who first adopted it and why? Who resisted it and why?
2. Discuss various technologies and show how they have developed at different rates. What are the issues that cause some to develop rapidly and others slowly? What technologies have been replaced over time, and why? Are there technologies that did not develop, and were there issues that caused them to disappear?
3. The teacher should also point out the sequence of adopters, which are typically categorized as early (innovators), second wave (early majority), and mass (great majority), as well as the resisters.
4. The teacher may also introduce the types of needs that are served by technology: basic needs (survival), safety, social (belonging), self-esteem (internal rewards), and self-actualization (self-fulfillment).

Exploration

1. Each student will select an historical or developing technology to research. Examples may include radio, TV, computer, steam engine, plastics, nuclear power, genetically altered foods, etc.
2. The student will research the development of the technology, examining the issues that affected its adoption, who adopted it and why, who resisted the new technology and why, problems encountered with its adoption, needs served by the adoption, what it may have replaced, and spin-off technology that may have resulted from its adoption.

Explanation

1. The teacher will need to work with individual students to help them locate and organize the types of information required by this assignment.
2. The teacher will need to encourage individual students to locate information missing from the categories listed above to help the students gain a greater understanding of the technology adoption.
3. The teacher may review how to organize, structure, and edit a good position paper, or have another teacher present the details. The student's outline should be examined prior to the beginning of the writing stage.

Extension

1. Students will organize the material they have researched into a manageable table.
2. Students will generate an outline from their information to aid in the development of their paper.
3. Students will generate a draft of their position paper, including the introduction, body, and conclusion, with proper reference citations.
4. Students will edit and develop new drafts of their paper as needed, with help from their teachers.
5. Students will make a brief presentation of the paper to the class (3-5 minutes).

Evaluation

Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for research, report, and presentation.

Additional Extension Activities

1. Students may research a technology that is currently being emphasized or discussed in another class, or was researched in one of the first two lessons.
2. Student work from the whole class can be collated into a class publication, either in print form or on a CD or other storage medium.
3. Students can compare different technologies and look for patterns of adoption. Look for adoption rates, people, problems encountered, needs satisfied, or spin-offs. They can also examine different periods of time and locate periods of many adoptions and discuss why that happened.

Laboratory-Classroom Preparation

Students should have access to information gathering and research, computers and software for word processing, and examples of sound papers with proper referencing.

Tools/Materials/Equipment

Research materials and Web access
Computers/software
Printers

Laboratory-Classroom Safety and Conduct

Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.

Photovoltaics, attached to the hood of this electric car, have possible risks and benefits.

Assignment – Lesson 1-3
Examining a Technology and its Adoption

Selecting a Technology

Select an historical or current technology that has had (or is having) a social interaction. elect a technology that allows you to examine how it was adopted, how long it took to adopt, and what issues were involved in its adoption (or rejection). You may need to review several references to find the social connections. Be sure to record the publishing information for each reference you use. A few technology examples are provided here, and are categorized:

Information: printing press, radio, television, camera, computer, cell phone
Manufacturing: plastic products, manufactured house, ordering products online, automation
Transportation: steam engine, power steering, bicycle, electric vehicles, hybrid vehicles
Construction: plywood, balloon framing, steel beams, owner-builder housing, concrete
Biotechnology: genetically altered foods, radiated foods, new drugs, artificial limbs or organs
Technology and Design: plow, plastics and new materials, refrigeration, nuclear power, laser

Technology Adoption

As you research, record the information on your worksheet. Was the technology introduced quickly, or did it take many years to be accepted? Was the technology rejected or resisted at first, and why? Who adopted it early (innovators), who was the second wave of adopters (early majority), and who finally adopted it (great majority)? Were there people who never accepted it or who tried to eliminate it? What social institutions were most affected? What needs were served by the technology—basic needs (survival), safety, social (belonging), self-esteem (internal rewards), or self- actualization (self-fulfillment)? You can use the worksheet as you research, and later use it to prepare your report. The worksheet chart can be reproduced as needed.

Report

Once your research is completed, you can summarize your findings in a short report. The report should be no more than three pages, double-spaced, using a word processor. Be sure to include your bibliography. If your teacher requests it, you may want to hand in a draft prior to the final report.

Presentation

Prepare a five-minute verbal presentation of your report. You may want to develop an outline of the important points in your report. When you present, try not to simply read the report, but present your main findings. Use a well-projected and clear voice, and try not to rush the presentation. You may want to practice the presentation at home first to family or friends. Allow time for the audience to ask questions.

Assignment Worksheet – Lesson 1-3

Student Name: **Technology:**

Date:

Research (copy as needed)

Type of Issue	Broad Concepts	Sub-Concepts	Sub-Sub-Concepts
Technology			
Science			
Mathematics			
Social Studies			
Arts			
Social Sciences			
Other _____			

Bibliography (list all sources used)

Outline and Notes for Report

Outline for Presentation

Unit 1 – Lesson 4

Technology Alternatives: Benefits and Risks

Lesson Duration: Four (4) hours.

STL Standards

- Students will develop an understanding of the relationships among technologies and the connections between technology and other fields. (3)
- Students will develop an understanding of the effects of technology on the environment. (5)
- Students will develop an understanding of the role of society in the development and use of technology. (6)
- Students will develop the abilities to use and maintain technological products and systems. (12)

STL Benchmarks

- Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. (3H)
- Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment. (5L)
- The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. (6I)
- Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. (12P)

Learning Objectives

Upon completion of this lesson, students will be able to;

1. Define benefits and risks in terms of technological innovation.
2. Examine technology alternatives in terms of benefits and risks.
3. Evaluate risks and benefits for a variety of groups and time periods.
4. Describe how a risks/benefits analysis may reduce technological issues.
5. Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population.
6. Use representations to model and interpret physical, social, and mathematical phenomena.
7. Classify information on technology, assuming that the design of a device or process must include how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.
8. Construct analysis based on the fact that the value of any given technology may be different for different groups of people and at different points in time.
9. Apply risk analysis to minimize the likelihood of unwanted side effects of a new technology, realizing that the public perception of risk may depend on psychological factors as well as scientific ones.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.

1-4A.
1-4B.
1-4C.
1-4D.
1-4E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did their part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on them.	Went beyond what was expected of them.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Research

Category	Below Target	At Target	Above Target
Variety of Sources	Used very little or varied sources.	Used multiple sources with multiple perspectives.	Used many sources with a variety of viewpoints.
Documentation	Little or inadequate documentation.	All sources documented and done so properly.	Documentation was well developed and referenced.
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.

Assessment Instrument – Analysis/Presentation

Category	Below Target	At Target	Above Target
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.
Organization	Presentation is not well organized and is hard to follow.	Presentation is well organized and easy to follow.	Presentation is exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation was creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Research	As per above			
Analysis/ Presentation	As per above			

Resource Materials

- Print-Based Sources
  Engineering by Design (1999) Gerard Voland
  Technological Risks (1992) H. W. Lewis
- Audiovisual Materials
  History: The Temptation of Technology Vol. 1- Clean up of Bar Harbor (videoproject.com)
- Internet Sites
  www.cpsc.gov/indexmain.html – CPSC is an independent Federal regulating agency for safe and reduced-risk products

Purpose of Lesson:

To allow students to examine the benefits and risks of technology from a variety of viewpoints.

Required Knowledge and/or Skills:

Students should have the ability to research a variety of mediums and be able to organize the information into a table or chart for presenting.

Lesson 1-4:

Engagement

1. The teacher may begin the discussion by examining our energy alternatives. The benefits and risks of each alternative should be discussed, including to whom and when the benefits and risks occur. For example, acid rain from burning fossil fuels (or more correctly, acid deposition) may affect people far from the source of the technology. Greenhouse gases, which have been accumulating since the beginning of the industrial period, may not show signs of effect until a future date. Discuss with students examples of technology, both historical and current.
2. The teacher should note that benefits and risks are not solely technological, as explored in earlier lessons in this chapter. Examples of each should be presented.
3. The teacher should conclude by having the students brainstorm current or upcoming technological issues that may require a risks/benefits analysis. Some examples may include: increasing food production, waste handling, construction methods, manufacturing materials selection, planning a new highway, tool design, alternative fuels, etc.

Exploration

1. Working in small groups, students will examine a technological problem or issue and research potential risks (which may also include costs) and benefits.
2. After carefully defining the problem, the students should identify 3-4 alternative solutions to the problem.
3. For each solution, students should research potential benefits and risks, identifying who and when the risks or benefits will be incurred. They should carefully describe each benefit or risk. All sources should be appropriately documented.

Explanation

1. Student groups may briefly describe their technology to the class, and solicit suggestions on alternatives, benefits, and risks that they may want to research.
2. The teacher will work with each group to help them select alternatives and identify and categorize various benefits and risks.
3. Students may use the lesson worksheet to collect and organize their research.

Extension

1. Students will research, collect, and organize their data, documenting all references.
2. Students will analyze their data and determine which information should be used in their presentation.
3. Students will develop a visual chart, table, or other database summarizing their findings.
4. Students will make a brief presentation (3-5 minute) of their chart.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, research, and analysis/presentation.

Additional Extension Activities

1. Students may select current events of technological issues as identified in the news or discussed in other classes.
2. Student presentations may be displayed in a prominent location in the school for viewing by other students and staff.
3. Class work from all groups can be collated into a media presentation, brochure, CD, or other

storage medium for distribution.

Laboratory-Classroom Preparation
Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations.

Tools/Materials/Equipment
Research materials and Web access
Computers/software
Printers
Poster/sign maker
Media projector

Laboratory-Classroom Safety and Conduct
Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.

Each technological device, including this electric car, has possible risks and benefits.

Assignment – Lesson 1-4
Technology Alternatives: Benefits and Risks

Selecting the Technological Problem

Select a current or emerging (future) technology that is or will create technological issues. You will be identifying the risks and benefits of the technology. Be sure to record the publishing information for each reference you use. A few technology examples are provided here, and are categorized:

Information: data implant in humans, biometric security scanning, internet censorship
Manufacturing: outsourcing jobs, solar power, scarcity of materials and water, nanotechnology
Transportation: alternative fuels, using nuclear power to make hydrogen, travel to Mars, automated cars/highways
Construction: using organisms for construction, smart houses, green buildings, space stations, colonization of other worlds
Biotechnology: artificial limbs or organs, cloning, stem cell research
Technology and Design: artificial intelligence, robots in the home, completely recyclable products

Researching the Issues

Based on the first three activities in this unit, identify potential issues that will need to be considered for the adoption of your technology. Identify potential risks and benefits, carefully define them, identify who is affected and when they may be affected. Next, research 3-4 possible alternatives, and develop information on their potential risks and benefits. Remember, there are no wrong answers here, we simply do not know what everything that the future may bring. The worksheet chart can be used to organize your research and can be reproduced as needed.

Analyzing

Once you or your team have completely exhausted all possible risks and benefits, you will need to organize them. What types of risks and benefits were identified? Do some risks seem too bad to allow them to occur? Do some benefits outweigh the potential risks? Do some people unfairly receive the risks, and/or not receive the benefits? Do any of the alternatives present less risks and more benefits?

Presentation

Develop a 3-5 minute presentation on your conclusions. Develop a graphic representation of your findings, including risks and benefits for all the alternatives.

Assignment Worksheet – Lesson 1-4

Student Name(s): **Technology:**

Date:

Research (copy as needed)

Technology	Define Risk or Benefit	Who is Affected	When they are Affected
Original Technology Risks			
Original Technology Benefits			
Alternative Technology 1 Risks			
Alternative Technology 1 Benefits			
Alternative Technology 2 Risks			
Alternative Technology 2 Benefits			
Alternative Technology 3 Risks			
Alternative Technology 3 Benefits			
Alternative Technology 4 Risks			
Alternative Technology 4 Benefits			

Bibliography (list all sources used)

Organize or Outline Risks and Benefits (rework as needed, use to develop your visual record)

Presentation Notes (use additional paper as needed)

Unit 2
Sources of Technological Issues

Engineering By Design
A National Model for Standards-Based Programs

Unit 2: Sources of Technological Issues

STL Standards

- Students will develop an understanding of the characteristics and scope of technology. (1)
- Students will develop an understanding of the core concepts of technology. (2)
- Students will develop an understanding of the relationships among technologies and the connections between technology and other fields. (3)
- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop an understanding of the effects of technology on the environment. (5)
- Students will develop an understanding of the attributes of design. (8)
- Students will develop the abilities to use and maintain technological products and systems. (12)
- Students will develop an understanding of and be able to select and use agricultural and related biotechnologies. (15)
- Students will develop an understanding of and be able to select and use energy and power technologies. (16)

STL Benchmarks

- Most development of technologies these days is driven by the profit motive and the market. (1M)
- Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. (2Z)
- Requirements involve the identification of criteria and constraints of a product or system and the determination of how they affect the final design and development. (2AA)
- Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function. (3G)
- The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees. (4K)
- Decisions regarding the implementation of technologies involve the weighing of trade-offs between positive and negative effects on the environment. (5L)
- Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. (8K)
- Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. (12P)
- Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality. (15M)
- Energy resources can be renewable or nonrenewable. (16M)

Mathematics Standards

1R Develop an understanding of large numbers and recognize and appropriately use exponential, scientific, and calculator notation.

6C Model and solve contextualized problems using various representations, such as graphs, tables, and equations.

20B Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.

22C Use representations to model and interpret physical, social, and mathematical phenomena.

Science Standards

8J In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.

8K The value of any given technology may be different for different groups of people and at different points in time.

21L Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.

22J The amount of life any environment can support is limited by the available energy, water, oxygen, and minerals, and by the ability of ecosystems to recycle the residue of dead organic materials. Human activities and technology can change the flow and reduce the fertility of the land.

37P Agricultural technology requires tradeoffs between increased production and environmental harm and between efficient production and social values. In the past century, agricultural technology led to a huge shift of population from farms to cities and a great change in how people live and work.

39P Industrialization brings an increased demand for and use of energy. Such usage contributes to the high standard of living in the industrially developing nations but also leads to more rapid depletion of the earth's energy resources and to environmental risks associated with the use of fossil and nuclear fuels.

39Q Decisions to slow the depletion of energy sources through efficient technology can be made at many levels, from personal to national, and they always involve tradeoffs of economic costs and social values.

Big Idea:
Technological issues can result from the technology itself, how or where it is transferred, or how it interacts with the limitations of the environment or ecosystem.

Unit 2 Objectives

At the completion of this unit, students will be able to:

- Examine various economic (market) and social issues that affect the development of technology.
- Evaluate the issues related to the transfer of technology within and between cultures.
- Examine attributes of design that may contribute to sources of technological issues.
- Determine limits of resources and their impacts on technological development.

Assessment

Assessment for each lesson includes a quiz, and rubrics will be used for group work and/or parts of the research, analysis, and presentation.

Teacher Preparation

Teacher preparation for this unit should include:

- Gather references, or make available, examples of historical changes and technological innovations and inventions. As students discover good references, Web sites, films/documentaries, local historical sites, etc., develop a database.
- Research historical events to examine their technological and social interactions. Develop a list of potential topics for the students.
- Discuss with other teachers what students are studying in their classes, including history, economics, social studies, science, mathematics, and other technology classes, and how those concepts are related to technological issues.
- Gather examples of technological and/or social issues that are current from news articles or media presentations.
- Review teaching methodologies used in Lessons 1 – 4.
- Make copies of the assignments (one page, double-sided if need be) and the worksheets (one page, double-sided if need be) for each student or group.

Unit 2 – Lesson 1

Examining Exponential Growth

Lesson Duration: Four (4) hours.

STL Standards
- Students will develop an understanding of the characteristics and scope of technology. (1)
- Students will develop an understanding of the core concepts of technology. (2)
- Students will develop the abilities to use and maintain technological products and systems. (12)

STL Benchmarks
- Most development of technologies these days is driven by the profit motive and the market. (1M)
- Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. (2Z)
- Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. (12P)

Learning Objectives
Upon completion of this lesson, students will be able to:
1. Examine population and economic systems in terms of their growth.
2. Evaluate how exponential growth rates exceed linear growth rates, and how they affect population, economies, and world resources.
3. Explore the concept of doubling time and how it may affect economic, technical, and social issues.
4. Calculate growth rates and impacts of technological exponential growth.
5. Develop an understanding of large numbers and recognize and appropriately use exponential, scientific, and calculator notation.
6. Model and solve contextualized problems using various representations, such as graphs, tables, and equations.
7. Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.
8. Realize that industrialization and economic growth bring an increased demand for and use of energy.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (see Appendix E for pre/post test)
Directions: Select the response that best answers the question.

2-1A.
2-1B
2-1C.
2-1D.
2-1E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on them.	Went beyond what was expected.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of other. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Calculations

Category	Below Target	At Target	Above Target
Organization of the Problem	Problem not well defined or understood.	Problem well defined and understood.	Problem well defined and articulated, all variables well documented.
Using calculations and/or formulas	Incorrect formulas used or correct formulas used incorrectly.	Formulas were selected and used appropriately.	All correct formulas were selected and used properly and were checked using alternative methods.
Documenting the Calculations	Documentation of the work was messy or hard to follow.	Problem solution was easy to follow and neatly done.	Problem solution was exceptionally well documented and clearly laid out.

Assessment Instrument – Analysis/Presentation

Category	Below Target	At Target	Above Target
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.
Organization	Presentation is not well organized and is hard to follow.	Presentation is well organized and easy to follow.	Presentation is exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation was creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Calculations	As per above			
Analysis/ Presentation	As per above			

Resource Materials

- Print-Based Sources
  - *The Limits to Growth* (1972) D. Meadows et.al.
  - *Human Scale* (1980) Kirkpatrick Sale
- Audiovisual Materials
  - *Population and World Resources* (libraryvideo.com)
  - *World in Balance: The Population Paradox* (libraryvideo.com)
- Internet Sites
  - www.science.org.au/nova/020/020box03.htm Information on exponential growth and population from Australian Academy of Science
  - www.learner.org/exhibits/dailymath/population.html from Annenburg CPB Learning, information on exponential growth and population

Purpose of Lesson

To examine the effects of exponential growth on population, the economy, and how growth may create technological issues.

Required Knowledge and/or Skills

Students should have the ability to perform algebraic and exponential calculations, and be able to project mathematical models onto technological and economic issues.

Lesson 2-1:

Engagement

1. The teacher will begin with a discussion of how linear growth and exponential growth differ. A simple model can be used: Show how a $100 bank account earning $5 per year would yield $170 after 14 years; however, earning 5% per year, the bank account would double to $200 in 14 years.
2. Students should discuss growth rates as reported in the news for local, regional, and world-wide economic growth rates. Typically, economists look for a growth rate between two and eight percent. Doubling time—the amount of time necessary for a quantity to double is size at a given rate—can be quickly estimated (using an estimate based on logarithms). Doubling time can be calculated by dividing the rate, as a whole number, into seventy. For the example above, the bank account growing at a rate of 5% (.05) will double in 70/5, or 14 years. Calculate the doubling time for the local, regional, or national growth rate.
3. Discuss how exponential growth rates, although they may be good for growing your bank account, may affect economic systems and create technological issues with population and resources (food, energy, materials, land/soil, water, etc.).

Exploration

1. Students may work individually or in small groups to make the calculations in Part 1 below.
2. After discussing the responses to Part 1, students should work in small groups to complete one of the scenarios in Part 2: List of Problems.
3. Students will develop a handout explaining their methods and analysis to their problems.

Explanation

1. The teacher should lead the discussion of responses following Part 1. He/she may want to show that, not only is population growing exponentially, but the rate changes also, as we make technological and scientific advances (as shown in the following simple table):
2. The teacher may direct student groups into the specific list of problems; all problems should be covered by at least one group.
3. The teacher should explain that there are several ways to solve each problem. The teacher may need to help with the calculations or seek help from the math teacher.
4. The teacher should lead a discussion on the four questions following Part 2.

Extension

1. Students will calculate and show all work for problems in Parts 1 and 2.
2. Students will discuss the questions in Part 2 first in their small groups, and then with the whole class.
3. Students will develop a handout summarizing the problem the worked out in Part 2. They will explain the handout in a short (2-3 minute) presentation.

Evaluation:

Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, calculations, and analysis/presentation.

Additional Extension Activities

1. Students may identify additional technological issues that may be affected by exponential growth.
2. Students may use growth rates to predict how much items (food, cars, clothing, etc.) will cost in 10, 20, 50, and 100 years based on the current inflation rate (use doubling times).

Growth rates from history:

Date	Growth Rate	Population	Doubling Time	Advances
1650	0.3%	.5 billion	250 years	
1970	2.1%	3.6 billion	33 years	Longer lifespan, advances in medicine, increased fertility rates
Current	Under 2%	Over 6 billion	Less than 30 years	Population and birth control information disseminated worldwide

3. Student presentations can be displayed in a prominent location in the school for a period of time.
4. Student presentations can be collated into a media presentation (graphic, CD, or other).

Laboratory-Classroom Preparation
Students should have access to calculators, room for small group and whole class discussion, and media and equipment for graphic production and presentations.

Tools/Materials/Equipment
Calculators
Computers/software
Printers
Poster/sign maker

Laboratory-Classroom Safety and Conduct
Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.

Assignment – Lesson 2-1
Examining Exponential Growth

Part 1: Sample Problem in Exponential Growth and Doubling Time

Try these examples: (show your work on a separate sheet):

1. You invest $500 in a banking account, which will pay an interest rate of 4% per year. How long will it be before your initial investment is worth $1,000? How long will it be before you have a nest egg of $4,000? Remember that you are not adding $4 per year, but your money is growing at a rate of 4%. What other human activities grow exponentially?

2. Your family owns a pond. One day you notice a new water plant in the pond. The next day the plant has doubled in size. When you check with a local biologist, he informs you that it is a type of plant that will fill the pond in thirty days. For the first couple days, the plant is still small compared to the pond. If you consider not worrying about the plant until it covers half the pond, what day is that? When do you realize you have a problem? What day is the pond only 3% full? What if you dug the pond out to four times its original size, how much extra time would you have before the pond was full? How does this relate to world population and our ability to provide adequate technology?

3. An old Persian legend relates the tale of craftsman who presented the King with a well-crafted chessboard. In return, he asked the King to provide him with one grain of rice on the first square, two on the second square, four on the third square, and so on. The King, thinking this was a modest request, ordered rice to be delivered. Knowing that the chessboard is eight squares by eight squares, how much rice was delivered (and was this possible)?

Discussion

Once you have completed these exercises, discuss your solutions with the whole class.

A. Describe what we have learned about exponential growth.

B. Describe what doubling time means.

C. How does exponential population growth compare to other technologies that may only grow in a linear fashion? What will eventually happen?

D. Describe technological or social solutions to help control exponential growth. Are they feasible, or do they have problems?

Be prepared to discuss these questions (both your method and answer) with the class.

Part 2: Exponential Growth and Technology

In small groups, examine the problems on the list below. Carefully calculate your results, and check your math several times. Neatly record all of your work. Carefully and creatively design a one-page handout of your findings. Include the following: statement of the problem, neat and clear mathematical explanation, and full sentence responses to the three questions listed below.

List of Problems

1. Information
Current trends show that computer memory doubles every 20 months. Calculate the growth rate. Based on the current model of computer available, develop a table of memory sizes for the next ten years in two-year intervals. For each interval, determine how much information could be stored on a personal computer, based on number of books, music files, movies, newspapers and/or other mediums of average sizes.

2. Manufacturing
Assume that our inflation rate for the next 60 years will be about 3% per year. Develop a table showing the costs for manufactured goods in 15, 30, 45, and 60 years hence. Items may include tools, food, automobiles, furniture, household goods, etc. You will need to provide a column showing current prices. In the sixty year period, will the costs double?

3. Transportation
Select a city near your location and determine its size in square miles or acres. Assume the city is planning for 4% growth to stay competitive. Currently, assume that the city has roughly 1% of its land area covered in asphalt or concrete (including roads, parking lots, driveways, etc.). Assuming that the city will not purchase any new land, determine when the whole city will be paved over, based on the growth rate. Based on four inches of concrete or asphalt, determine the total volume of material needed for the job.

4. Construction
Your state planners are determined to increase the state's population by 5% per year to increase revenue (from taxes). They have determined that each person requires a minimum of 400 square feet of living space and 200 square feet of working space (average per person). Based on the state's land area and current population, when will all the land be taken up by buildings to meet the projected growth rate?

5. Biotechnology
Assume that the world's population is growing by 2%, which includes birth rates and death rates. Use current world population (or 2002 population of approximately 6 billion) for your calculations. Assume the average weight of a human to be about 100 pounds, or 220 kilograms. Scientists have determined that the mass of the earth is 6.595 x 1021 tons, or 5.983 x 1024 kg. For each doubling time of the world population, based on 2% growth, determine the mass of all people, and determine how soon the mass of the people equals the mass of the planet.

6. Technology and Design
Develop your own problem (similar to those above), and provide a solution.

Assignment Worksheet – Lesson 2-1
Part 2: Exponential Growth and Technology

Student Names: **Problem # _____**

Date:

Record your information below and use it to develop your group handout. The information below may be in draft form, but you are encouraged to complete this sheet neatly so you are later able to use the information on the handout you develop:

Statement of the Problem
In your own words, carefully define the problem:

Calculations
Show all work.

Analysis of the Problem (Questions 1-4)

1. Describe the possibility of this scenario occurring, and why.

2. In what ways could technology or social intervention alleviate this problem, and will those solutions cause other problems?

3. Describe alternative technologies or policies that could be used to solve the problem.

4. Describe the problems you encountered in this activity and how you were able to solve them.

Handout Ideas and Layout

Unit 2 – Lesson 2

Evaluating Technology Transfer

Lesson Duration: Six (6) hours.

STL Standards

- Students will develop an understanding of the relationships among technologies and the connections between technology and other fields. (3)
- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop the abilities to use and maintain technological products and systems. (12)

STL Benchmarks

- Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function. (3G)
- The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees. (4K)
- Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. (12P)

Learning Objectives:

Upon completion of this lesson, students will be able to:

1. Define quality of life and standards of living in their own terminology.
2. Define technology transfer and give examples locally, regionally, and internationally.
3. Examine and analyze historical or current technology transfer projects.
4. Evaluate a technology transfer project for technological and social issues.
5. Categorize issues, recognize successes, and suggest solutions or alternatives to problems.
6. Present the analysis of a technology transfer project.
7. Use representations to model and interpret physical, social, and mathematical phenomena.
8. Recognize that the value of any given technology may be different for different groups of people and at different points in time.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.

2-2A.
2-2B.
2-2C.
2-2D.
2-2E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of other. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Research/Analysis

Category	Below Target	At Target	Above Target
Variety of sources	Used very little or varied sources.	Used multiple sources with multiple perspectives.	Used many sources with a variety of viewpoints.
Documentation	Little or inadequate documentation.	All sources documented and done so properly.	Documentation was well developed and referenced.
Reflection	Analysis showed little effort.	Analysis thorough and well thought out.	Analysis exceptionally well thought out showed keen insight.

Assessment Instrument – Presentation

Category	Below Target	At Target	Above Target
Organization	Presentation not well organized and is hard to follow.	Presentation well organized and easy to follow.	Presentation exceptionally well organized and flows very well.
Creativity	Presentation not very creative and was somewhat boring.	Presentation creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.
Feedback	Audience did not participate in the presentation.	Audience attentive to the presentation and participated when asked.	Audience extremely interested and asked many questions.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Research/ Analysis	As per above			
Presentation	As per above			

Resource Materials

- Print-Based Sources
  - *Introduction to Design and Technology* (1996) R. Todd et.al.
  - *Technology and the Quality of Life* (1996) Council on Technology Education
  - *Contemporary Technology* ((1989) Linda Rae Market
- Audiovisual Materials
  - *Seeds of Plenty, Seeds of Sorrow* –
    the darker side of the green revolution (bullfrogfilms.com)
  - *Talk Mogadishu: The Story of Horn Afrik* –
    the first community TV and radio station in Somalia (bullfrogfilms.com)
- Internet Sites
  - www.nttc.edu/ National Technology Transfer Center home page
  - www.itdg.org/ International Technology Development Group homepage

Purpose of Lesson

To examine case studies of technology transfer projects to see what problems occurred from the technology or social issues.

Required Knowledge and/or Skills

Students should have the ability to research a variety of mediums (print, Web, audiovisual), graphically represent the information, and analyze its content. The use of materials and information from other lessons and classes (disciplines) should be encouraged.

Lesson 2-2:

Engagement

1. The teacher should begin with a discussion on quality of life—what does that mean to the students? We are bombarded daily by advertisers attempting to sell us a product or service to help us live better. We are made to think that if we do not purchase their product, we may not have the quality of life we "deserve" for ourselves. Have students reflect for a moment on what constitutes quality of life, and how we measure it.
2. What is quality of life? Ask the students to generate a list of items to help define this concept. They should of course list items that define our basic human needs—shelter, clothing, food, water, sanitation, health needs. Discuss Abraham Maslow's hierarchy of needs, which he identified as levels of need that get more sophisticated as the lower levels are filled, and help a person achieve a happy, balanced life. The five levels include: physiological (basic or survival), safety (also survival), social (belonging), self-esteem (internal, self-respect), and self-actualization (fullest potential). The higher levels represent social needs that are sometimes much harder to measure.
3. The discussion should progress to a discussion of "standard of living" and some of the ways it is measured. How does the student's region or state compare to the rest of the country? How does the U.S. compare to other countries? Standard of living is a related concept; again, the meaning of this concept is open for discussion. In this country, standard of living is linked to the gross national product (GNP), which is a measure of all products and services. However, as many have pointed out, it also includes health services for accident victims, police services for crime, cost of cleaning up pollution, and other "non-productive" economic activities. It still does not measure those tangible social factors. Additionally, it has been brought to our attention that countries such as Sweden have a comparable standard of living with a much smaller GNP. It is even clear that some communities in this country are less well off than others.
4. Explain that one method of improving the standard of living, is to transfer technology. In history, once we improved our methods of transportation, technology spread at a quicker pace. The students should be informed that technology transfer can be for a variety of reasons: social needs, economic needs, technological needs, military needs, etc.

Exploration

1. Working in small groups, students will examine an historical or current technology transfer project.
2. Students will research the project and document successes, problems encountered, solutions suggested, for both technological and social issues (may use those identified in Lesson 1 in Unit 1).
3. Students will organize their information, make suggestions for problems that were not solved, and present their analysis.

Explanation

1. The teacher may provide a list of possible technology transfer projects (may be an infrastructure such as a railway, a process such as assembly line, or a device such as a cell phone).
2. The teacher will work with each group of students to help them locate information and help them organize their findings.
3. An informal presentation to the whole class may lead to suggestions on how problems could be solved, based on results from another group's research.

Extension

1. Students will collect information and document their sources. When possible, pictures or images should also be collected for student presentations.
2. Students will categorize the information they collect. The worksheet may help them organize the information.
3. The students should analyze the information, determining what worked well (successes), problems encountered, and solutions that were applied to the problems or solutions they recommend.
4. Students will prepare their information and present their findings to the class.

Evaluation

Student's knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, research/ analysis, and presentation.

Additional Extension Activities

1. Students may select a project that links to a current social studies or language curriculum, or may relate to a visiting exchange student.
2. Student presentations can be displayed in a prominent place in the school.
3. Student work can be collated in a graphic or CD storage medium.

Laboratory-Classroom Preparation

Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations.

Tools/Materials/Equipment

Research materials and Web access
Computers/software
Printers
Poster/sign maker
Media projector

Laboratory-Classroom Safety and Conduct

Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.

Assignment – Lesson 2-2
Evaluating Technology Transfer

Selecting a Case Study

Select and research a technology transfer project in small groups. The project may be historical or current. The transfer may be between local regions, states, or countries. You may need to review multiple references to gather the required information. Be sure to document your sources. A few types of technology transfer projects are listed below, and are categorized:

Information: infrastructures (phone lines, cable lines, cell phone satellites), devices (phones, cell phones, computers), processes (digitizing, film, news reporting, GPS)
Manufacturing: products (such as Coka-Cola™), assembly lines, automation, marketing, trade agreements, just-in-time manufacturing
Transportation: infrastructure (waterways, railroads, highways, roads), devices (jets, boats, tractors, railroad cars, Maglev), process (traffic management, inventory control)
Construction: new materials, building techniques, modifications and/or devices to withstand adverse weather, modular, manufactured construction
Biotechnology: sanitation methods, genetically altered plants, cloning techniques, new medicines and vaccinations, organ transplants
Technology and Design: appropriate technologies, intermediate technologies, alternative technologies, ergonomic designs

Examining the Transfer

Carefully examine all aspects of the selected transfer project. Start by documenting any background information, such as: group transferring the technology, group receiving the technology, details of the technology (devices, processes, etc.), what technology is to be replaced, dates of transfer, others involved (special groups, governments, etc.), and intended goal of the project.

Next, carefully examine successes as well as problems and solutions encountered during the transfer. You should be able to categorize them as technological or social issues based on your work from Chapter 1. You can use the table below on the worksheet to document your research. Be sure to document your sources. As you research, be aware of clues and ideas that will help you analyze the transfer project and make recommendations for improvement in the next section.

Analysis

Following your examination of the technology transfer project, reflect on what worked and what did not, and why. Was the technology successfully transferred? What adjustments were made during the transfer process? Were the people who received the technology open to the transfer? Were the people who received the technology able to fully use the technology (did they have the necessary infrastructure)? Did the technology improve the quality of life or standard of living of the recipients? How did the technological and social issues overlap?

Next, develop suggestions that may help (or have helped) the transfer project. Develop strategies that include both technological and social changes. You may need to examine similar transfer projects to develop your suggestions. You can use the following table on the worksheet to develop your ideas.

Presentation

Develop a presentation model showing details of the technology transfer project you investigated. Include drawings and photos if possible. Include your findings, your analysis, and your suggestions for improvement. Creativity is encouraged, along with proper design techniques and neatness. Share your final presentation with the class.

The transfer of technology, including this student-designed alternative transportation device, requires a study of how it will be used (complexity, access to fuel) and how it will be maintained (available infrastructures).

Assignment Worksheet – Lesson 2-2

Student Name(s) **Date:**

Project Name:

Background Information
Provide background information about the technology transfer project; be sure to include your sources (examples listed on the handout) :

Examination
Use the table to compile your research information (copy as needed).

	Technological Issues	Social Issues
Successes		
Problems Encountered		
Solutions Presented		

Bibliography Notes

Analysis

Use the table below to record your suggestions (copy as needed).

	Technological Suggestions	Social Suggestions
Problems Encountered		
Your Suggestions		

Presentation Ideas

Sketch, draw, or annotate ideas you would consider for your presentation. Be creative and follow appropriate design processes.

Unit 2 – Lesson 3

Lesson Title: Issues from Engineering Design Failures

Lesson Duration: Four (4) hours.

STL Standards
- Students will develop an understanding of the characteristics and scope of technology. (1)
- Students will develop an understanding of the core concepts of technology. (2)
- Students will develop an understanding of the attributes of design. (8)

STL Benchmarks
- Most development of technologies these days is driven by the profit motive and the market. (1M)
- Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. (2Z)
- Requirements involve the identification of criteria and constraints of a product or system and the determination of how they affect the final design and development. (2AA)
- Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. (8K)

Learning Objectives
Upon completion of this lesson, students will be able to:
1. Identify engineering design constraints and criteria.
2. Define types and examples of engineering design failures.
3. Examine design examples that have resulted in failure.
4. Analyze design failure and make recommendations for correction.
5. Recognize that when engineers design a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.

Student Assessment Tools and/or Methods
Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.
2-3A.
2-3B.
2-3C.
2-3D.
2-3E.

Assessment Instrument – Paper

Category	Below Target	At Target	Above Target
Organization	Paper not well organized —hard to follow.	Paper well organized and easy to follow.	Paper exceptionally well organized and flows very well.
Components	Components missing, little or no documentation.	Established good introduction, body, and conclusion.	All components well fulfilled and body of paper flowed well.
Grammar/ Spelling	Many spelling errors and grammatical mistakes.	Very few spelling errors or grammatical mistakes.	No spelling errors and exceptional grammar.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected of him/her.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Analysis

Category	Below Target	At Target	Above Target
Organization	Details not well organized —hard to follow.	Details well organized and easy to follow.	Details exceptionally well organized and flow very well.
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.
Insight	No new ideas suggested or presented.	Incorporated much of the research into the analysis.	Developed new ideas based on much research and insight from new perspectives.

Assessment Instrument – Presentation

Category	Below Target	At Target	Above Target
Organization	Presentation not well organized—hard to follow.	Presentation well organized and easy to follow.	Presentation exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.
Feedback	Audience did not participate in the presentation.	Audience was attentive to the presentation and participated when asked.	Audience was extremely interested and asked many questions.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Paper	As per above			
Analysis	As per above			
Presentation	As per above			

Resource Materials

- Print-Based Sources
  - *Engineering by Design* (1999) Gerard Voland
  - *Design Paradigms: Case Histories of Error & Judgement in Engineering* (1994) Henry Petroski
- Audiovisual Materials
  - *Living Under the Cloud: The Chernobyl Disaster* (bullfrogfilms.com)
  - *In Our Own Backyard* – the first brush the US had with toxic waste at Love Canal (bullfrogfilms.com)
- Internet Sites (use key word engineering failure in Web search)
  - www.lib.uiowa.edu/eng/failbiblio.htm – University of Iowa resources on engineering failures
  - www.englib.cornell.edu/ice/lists/historytechnology/successfail.html – Cornell University list of engineering successes and failures

Purpose of Lesson

To examine the entire design process to see where compromises may lead to technological issues over product failures.

Required Knowledge and/or Skills

Students should be able to use simple tools to dismantle technology devices safely, and be able to analyze them for improper or inadequate designs.

Lesson 2-3:

Engagement

1. The teacher should begin with a discussion of some major engineering design failures, which may include: Leaning Tower of Pisa, Love Canal, Chernobyl nuclear accident, Titanic, Tacoma Narrows Bridge, NASA's Challenger shuttle, etc. Included in the discussion should be what failed, who was affected, and what changes were made following the problem.
2. Discuss why accidents of this nature are investigated, and what changes result.
3. The teacher should collect a variety of small tools, household devices, etc. that have failed, or have students bring in examples.
4. The teacher should point out potential design problems or issues that may occur in a variety of situations, including: during manufacturing, during use, ease of maintenance, or ease of disposal or recycling. The market the product was designed for (low-end up to high-end) should also be discussed, and how that affects the criteria, constraints, and cost. Discuss how each of these factors affects how an engineer selects criteria or constraints.

Exploration

1. Students will develop a short paper on a serious engineering failure, documenting what happened, what failed, who was affected, and what corrections were made following the problem.
2. Working in small groups, students will examine a small tool or device to determine how it failed. They should determine who it affected, what could have been different in the design, and how new criteria and constraints would have affected the cost or use of the product.
3. The students should also examine the design in terms of manufacturing, operation, maintenance, what market the product was designed for, and how the product is disposed of or recycled.
4. Students will present their analysis to the class using a method of their choice.

Explanation

1. The teacher should indicate that some failures can be identified by recognizing hazards, estimating the damage possible from the hazard, evaluating the potential injury (risk), and attempting to minimize the hazard. This can be done in the initial design by adhering to standards, as outlined by organizations such as: American National Standards Institute (ANSI), Underwriters Laboratories (UL), Society of Automotive Engineers (SAE), Occupational Safety and Health Administration (OSHA), the Consumer Product Safety Commission (CPSC), and the National Highway Transportation Safety Board (NHTSB).
2. Students should be given ideas and guidelines for their paper as a homework assignment. The handout on types of failures may be distributed to students and used for their papers and group work.
3. The teacher may work with the small groups to help them dismantle and analyze the device they have selected.
4. The teacher should work with the groups to help them organize their findings and should-provide guidelines for their presentations.

Extension

1. Students can briefly describe their individual papers, describing the types of issues encountered.
2. Students will organize their analysis of the group device, indicating all information discussed above (the worksheet may help them organize their material).
3. Students groups will make a brief presentation of their findings to the class.

Evaluation
Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for their paper, group work, analysis, and presentation.

Additional Extension Activities
1. The class may make a field trip to a local site of a design failure.
2. A guest engineering speaker may come to class to describe a design failure and how the issue was resolved.
3. Student papers can be collated into a graphic or computer medium.
4. Students may repeat their presentations at a local hardware or household store as part of a consumer awareness service.

Laboratory-Classroom Preparation
Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations. They should have tools and devices available for dismantling, along with bench space and hand tools for simple tasks.

Tools/Materials/Equipment
Research materials and Web access
Computers/software
Printers
Tools and devices for dismantling
Hand tools for dismantling
Poster/sign maker
Media projector

Laboratory-Classroom Safety and Conduct
Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.

Assignment – Lesson 2-3
Issues from Engineering Design Failures

Engineering Design Failure - Paper

Individually, develop a short paper on a design failure, based on the guidelines given by your instructor. Include the documentation what happened, what failed, who was affected, and corrections made following the problem. Include your resources.

Paper Guidelines

Selecting a Technological Device

Select a tool, toy, household device, or other small technological device that has failed for some reason or other. Discuss in your group some of the design criteria or constraints that were developed for the device.

Examine the device to determine how it failed. Determine who it affected, what could have been different in the design, and how new criteria and/or constraints would affect the cost or use of the product. Examine the design in terms of manufacturing, operation, maintenance, what market the product was designed for, and how the product is disposed of or recycled.

The following list includes some types of failures (use for Analysis) *Source: Voland, p. 316*

Level One: Physical

material fatigue
toxicity
excessive noise or vibration
inadequate structural integrity (leading to collapse)
corrosion
exposed moving part
electrical hazards

Level Two: Process Errors

misunderstood problem
errors in calculation
incorrect or faulty reasoning
information overload
improper operation or misuse
errors in packaging
inadequate training
errors in judgment
invalid assumptions for design
incomplete or incorrect supporting data
miscommunication of info, constraint, or expectations
errors in manufacturing
improper storage
carelessness

Level Three: Perspective of Attitude

unethical/unprofessional behavior
lack of motivation
indifference to others' difficulties or needs
impulsive behavior or decision making
inappropriate priorities, objectives, and values
isolated from the users
overconfidence

Assignment Worksheet – Lesson 2-3

Student Names:

Date:

Technological Device:

Device Inspection (use additional sheets if necessary)

Document the following (use words, diagrams, sketches, pictures, etc.):

How it failed.

Who was affected?

What could have been different in the design.

How would new criteria and constraints affect the cost or use of the product?

Identify problems of manufacturing.

Identify problems of operation.

Identify problems of maintenance.

Identify what market the product was designed for.

Identify how the product is to be disposed of or recycled.

Presentation

Present your analysis to the class, using a method of choice. Use this space to develop ideas for your presentation, or sketch on separate paper.

Unit 2 – Lesson 4

Examining Earth's Limited Resources

Lesson Duration: Six (6) hours.

STL Standards
- Students will develop an understanding of the core concepts of technology. (2)
- Students will develop an understanding of the effects of technology on the environment. (5)
- Students will develop an understanding of and be able to select and use agricultural and related biotechnologies. (15)
- Students will develop an understanding of and be able to select and use energy and power technologies. (16)

STL Benchmarks
- Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. (2Z)
- Decisions regarding the implementation of technologies involve the weighing of trade-offs between positive and negative effects on the environment. (5L)
- Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality. (15M)
- Energy resources can be renewable or nonrenewable. (16M)

Learning Objectives
Upon completion of this lesson, students will be able to:
1. Define the terms exhaustible, inexhaustible, and renewable in terms of energy, materials, water, soils, and other resources.
2. Research and estimate the availability of resources for technological maintenance (current levels of use) and growth.
3. Evaluate the effects of increased use and increases in population in determining life expectancies of available resources.
4. Evaluate the effects of conservation on available resources.
5. Describe and model conservation methods and other techniques available to extend the life of resources.
6. Develop understandings of large numbers and recognize and appropriately use exponential, scientific, and calculator notation.
7. Model and solve contextualized problems using various representations, such as graphs, tables, and equations.
8. Use representations to model and interpret physical, social, and mathematical phenomena.
9. Recognize that humans are part of the earth's ecosystem, and their activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.
10. Understand that the amount of life any environment can support is limited by the available energy, water, oxygen, and minerals.
11. Recognize that agricultural technology requires trade-offs between increased production and environmental harm and between efficient production and social values.
12. Explain how industrialization brings an increased demand for and use of energy.
13. Recognize that decisions to slow the depletion of energy sources through efficient technology can be made at many levels, from personal to national, and they always involve trade-offs of economic costs and social values.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.
2-4A.
2-4B.
2-4C.
2-4D.
2-4E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected of him/her.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Calculations/Analysis

Category	Below Target	At Target	Above Target
Using Calculations and/or Formulas	Incorrect formulas used. or correct formulas used incorrectly.	Formulas selected and used appropriately.	All correct formulas selected and used properly and checked using alternative methods.
Documenting the Calculations	Documentation of the work messy or hard to follow.	Problem solution easy to follow and neatly done.	Problem solution exceptionally well documented and clearly laid out.
Organization	Details not well organized and hard to follow.	Details well organized and easy to follow.	Details exceptionally well organized and flow very well.
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.

Assessment Instrument – Models/Presentation

Category	Below Target	At Target	Above Target
Model Development	Model poorly made and not representative of the technology.	Model well crafted and represents the technology accurately.	Model very well crafted and is very representative of the technology.
Model Details	Details missing or misrepresented.	Many details of the technology easily seen.	Model extremely detailed and accurate.
Organization	Presentation not well organized—hard to follow.	Presentation well organized and easy to follow.	Presentation exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Calculations/Analysis	As per above			
Models/Presentation	As per above			

Resource Materials

- Print-Based Sources
  - *State of the World* (each year) – Worldwatch Institute
  - *Energy Efficiency Manual* (1994) Donald Wulfinghoff
  - *Building a Sustainable Society* (1981) Lester Brown
- Audiovisual Materials
  - *Population and World Resources* – how the Earth supports its people and their activities (libraryvideo.com)
  - *Global Environmental Issues* (libraryvideo.com)
  - *On American Soil* – nature and extent of soil erosion in America (bullgfrogfilms.com)
  - *Our Vanishing Forests* – the history and policies of the US Forest Service (bullfrogfilms.com)
- Internet Sites
  - www.worldwatch.org – Worldwatch Institute homepage
  - www.wholeearthmag.com/resources.html – Whole Earth list of related Web sites, resources and conservation
  - www.nrcs.usda.gov/ – U.S. National Resources Conservation Service homepage (also each state has an energy resources division and/or conservation department)
  - www.thesca.org/ – Student Conservation Association homepage

Purpose of Lesson

To examine different types of resources necessary for technology, estimate how long they will last, examine factors that will increase their use, and explore and model alternatives.

Required Knowledge and/or Skills

Students should be able to research Earth's resources, determine life expectancies at current and future consumption rates, and design and model conservation devices or processes that enhance the life expectancies of resources.

Lesson 2-4:

Engagement

1. The teacher can begin by asking students to list as many energy sources as possible (oil, gas, coal, uranium, wind, solar heat, biomass, wood, tidal, waves, geothermal, photovoltaics, etc.). The students should be encouraged to place each source in one of three categories: exhaustible (will eventually run out or be too expensive to retrieve), inexhaustible (are available in very large quantities), or renewable (with wisdom, can be regenerated faster than depleted).
2. Students should discuss what percent of each category represents our current use of energy. What obvious conclusion can they draw?
3. Students should also discuss other resources, such as water, soil, and materials, using the same three categories.

Exploration

1. Working in small groups, students will select a resource to research: energy sources, fresh water, productive soil, specific materials (woods, metals, plastics), food supplies, clean air, etc.
2. The student groups will research how much of each resource remains, and how long it will last at our current rate of use.
3. The student groups will estimate how increases in population (exponential growth), and increases in use due to improvements in quality of life for people, will affect how long the resource will last.
4. The student groups will research conservation methods and determine how each may contribute to helping the resource last longer.
5. The student groups will develop a model of a conservation device or method to extend the life of each of their resource.

Explanation

1. The teacher may lead a discussion of resources, and/or students can bring examples from their other classes.
2. The teacher will work with the groups to help them identify information sources on their topic, and explain some of the issues. The Worldwatch Institute has many resources available, including somewhat dated material posted on its Web site for free.

Kevin uses recycled parts to design alternative bicycles.

3. The teacher will work with groups to determine a possible technique or device to model, and how the model may be constructed.

Extension

1. Students will select and research a resource used for technology, determining approximately how long the resource will last based on our current use and level of technology.
2. Students will estimate how population growth and increased technological development will affect the life of the resource.
3. Students will describe some methods available for conserving the resource, and approximately how the technique or device could extend the life of the resource.
4. Students will develop a conservation technique or device.
5. Student groups will present their research and models.

Evaluation

Students knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for their group work, calculations/analysis, and models/presentation.

Additional Extension Activities

1. Local speakers can address the class, including engineers, conservationists, extension workers, or others.
2. Students can give their presentations to local clubs or groups.
3. Students can tape their presentations and edit a final video production, including all resources.
4. Students can collate and document the class collection of resources, either graphically or on a form of computer storage.

Laboratory-Classroom Preparation

Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations. They should have workbench space and hand tools and materials available for modeling conservation devices and techniques.

Tools/Materials/Equipment

Research materials and Web access
Calculators
Computers/software
Modeling materials and tools
Printers
Poster/sign maker

Laboratory-Classroom Safety and Conduct

Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.

Assignment – Lesson 2-4
Examining Earth's Limited Resources

Selecting a Resource
Working with your instructor, select a resource to research: energy sources, fresh water, productive soil, specific materials (woods, metals, plastics), food supplies, clean air, or other. Research and use a calculator to examine the questions below.

Calculations/Analysis
Document all of your research resources. Determine the following estimates based on your research and any necessary calculations. Be sure to clearly show all calculations. You should realize that you are developing best-guess estimates; there are no right or wrong answers (although you want your estimate to reflect good research). These estimates are based on our current technology and could change in the future as newer technologies are developed.

1. Estimate how long your resource will last based on our current use and technology (this can be done by country, worldwide, or both).

2. Estimate how increases in population (current or expected growth rates) and increases in technological growth (as other people increase there standard of living) will affect how long your resource will last. You can estimate the effects separately, and taken together. Compare to your estimate in calculation number one above.

3. Identify technological devices and/or methods that may help conserve the resource you are researching. Estimate how each, and all collectively, will affect how long the resource will last. Compare your estimate with those in numbers one and two above.

Assignment Worksheet – Lesson 2-4

Develop Ideas for Your Technological Device/Technique

Problem statement: What is the intention of the device or technique?

Brainstorming Ideas and/or Sketches

Select Option and Provide Modeling Details

Describe Device/Technique Operation

Develop Presentation Ideas

Unit 3
Examining Technological Issues

Engineering By Design
A National Model for Standards-Based Programs

Unit 3: Examining Technological Issues

STL Standards

- Students will develop an understanding of the core concepts of technology. (2)
- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop an understanding of the effects of technology on the environment. (5)
- Students will develop an understanding of the role of society in the development and use of technology. (6)
- Students will develop an understanding of the attributes of design. (8)
- Students will develop the abilities to apply the design process. (11)
- Students will develop the abilities to assess the impact of products and systems. (13)

STL Benchmarks

- Requirements involve the identification of criteria and constraints of a product or system and the determination of how they affect the final design and development. (2AA)
- Ethical considerations are important in the development, selection, and use of technology. (4J)
- With the aid of technology, various aspects of the environment can be monitored to provide information for monitoring. (5I)
- The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. (5J)
- Humans devise technologies to reduce the negative consequences of other technologies. (5K)
- Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment. (5L)
- Different cultures develop their own technologies to satisfy their individual and shared needs, wants and values. (6H)
- Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. (8K)
- Identify criteria and constraints and determine how these will affect the design process. (11N)
- Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment. (13K)

Mathematics Standards

1Q Understand and use ratios and proportions to represent quantitative relationships

14H Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population

21C Recognize and apply mathematics in contexts outside of mathematics

22C Use representations to model and interpret physical, social, and mathematical phenomena

Science Standards

7K Technological problems often create a demand for new scientific knowledge, and new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research.

8J In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.

9Q Social and economic forces strongly influence which technologies will be developed and used. Which will prevail is affected by many factors, such as personal values, consumer acceptance, patent laws, the availability of risk capital, the federal budget, local and national regulations, media attention, economic competition, and tax incentives.

21L Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.

38N Waste management includes considerations of quantity, safety, degradability, and cost. It requires social and technological innovations, because waste-disposal problems are political and economic as well as technical.

Big Idea:
Examining why and what humans design, the constraints and limitations, and how the designs interact with society and the environment, helps us create designs and solve problems with fewer technological issues.

Unit 3 Objectives

At the completion of this unit, students will be able to:

- Examine how safety and quality of life affect the design of technology.
- Evaluate safety and ergonomic principles as criteria in the design of technology.
- Examine how ethics affect technological issues and the implications of product liability.
- Evaluate monitoring technologies that can be used to reduce technological issues with the environment.

Assessment

Assessment for each lesson includes a quiz, and rubrics will be used for group work and/or parts of the research, analysis and presentation.

Teacher Preparation

Teacher preparation for this unit should include:

- Gather references, or make available examples of historical changes and technological innovations and inventions. As students discover good references, Web sites, films/documentaries, local historical sites, etc., develop a database.
- Research historical events to examine their technological and social interactions. Develop a list of potential topics for the students.
- Discuss with other teachers what students are studying in their classes, including history, economics, social studies, science, mathematics, and other technology classes, and how those concepts are related to technological issues.
- Gather examples of technological and/or social issues that are current from news articles or media presentations.
- Review teaching methodologies used in Lessons 1-4.
- Make copies of the assignments (one page, double-sided if need be) and the worksheets (one page, double-sided if need be) for each student or group.

Unit 3 – Lesson 1

Design and Technology for Quality of Life

Lesson Duration: Six (6) hours.

STL Standards

- Students will develop an understanding of the core concepts of technology. (2)
- Students will develop an understanding of the role of society in the development and use of technology. (6)
- Students will develop an understanding of the attributes of design. (8)
- Students will develop the abilities to assess the impact of products and systems. (13)

STL Benchmarks

- Requirements involve the identification of criteria and constraints of a product or system and the determination of how they affect the final design and development. (2AA)
- Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values. (6H)
- Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. (8K)
- Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment. (13K)

Learning Objectives

Upon completion of this lesson, students will be able to:

1. Define quality of life in terms of technology and societal needs.
2. Assess quality of life using a variety of criteria.
3. Evaluate quality of life—compared regionally, nationally, and internationally.
4. Generate suggestions for improving quality of life in a variety of technological areas.
5. Formulate questions, design studies, and collect data about a characteristic shared by two populations (or different characteristics within one population).
6. Use representations to model and interpret physical, social, and mathematical phenomena.
7. Recognize that social and economic forces strongly influence which technologies will be developed and used, and include factors such as personal values, consumer acceptance, availability of capital, local and national regulations, media attention, economic competition, and tax incentives.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.
3-1A.
3-1B.
3-1C.
3-1D.
3-1E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected of him/her.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Research

Category	Below Target	At Target	Above Target
Variety of Sources	Used very few or insufficiently varied sources.	Used multiple sources, with multiple perspectives.	Used many sources with a variety of viewpoints.
Documentation	Little or inadequate documentation.	All sources documented and done so properly.	Documentation was well developed and referenced.
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.

Assessment Instrument – Analysis

Category	Below Target	At Target	Above Target
Organization	Details not well organized —hard to follow.	Details well organized and easy to follow.	Details are exceptionally well organized and flow very well.
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.
Insight	No new ideas suggested or presented.	Incorporated much of the research into the analysis.	Developed new ideas based on much research and insight from new perspectives.

Assessment Instrument – Presentation

Category	Below Target	At Target	Above Target
Organization	Presentation not well organized—hard to follow.	Presentation well organized and easy to follow.	Presentation exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation was creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.
Feedback	Audience did not participate in the presentation.	Audience was attentive to the presentation and participated when asked.	Audience was extremely interested and asked many questions.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Research	As per above			
Analysis	As per above			
Feedback	As per above			

Resource Materials

- Print-Based Sources
  - *Technology and the Quality of Life* (1996) Council on Technology Teacher Education
  - *Design for the Real World* (1985) Victor Papanek
  - *The Consumer's Guide to Effective Environmental Choices* (1999) M. Brower & W. Leon
- Audiovisual Materials
  - *Renewable Energy Solution Series* (videoproject.com)
  - *The Car* – auto designed for recycling (bullfrogfilms.com)
- Internet Sites
  - www.worldbank.org/lsms/ – Standards of living survey tools by the World Bank Organization (9)

Purpose of Lesson

To have students evaluate quality of life based on technological and social issues, compare their perceived quality of life to other regions, and provide suggestions for improvement.

Required Knowledge and/or Skills

Students should have the ability to research a variety of parameters related to quality of life, compare them regionally, nationally, and internationally, and make suggestions for improvements based on current technology.

Kristina and Amy help with a class project to refurbish a horse trailer to make it safer and easier to use.

Lesson 3-1:

Engagement

1. The teacher may begin by reviewing the Unit 2, Lesson 2 discussion of quality of life and its attributes from Chapter 2. Students should be able to list and give examples of items that define our basic human needs: shelter, clothing, food, water, sanitation, health needs. They should discuss Abraham Maslow's hierarchy of needs, which he identified as levels of need that get more sophisticated as the lower levels are filled, and help a person achieve a happy, balanced life. The five levels include: physiological (basic or survival), safety (also survival), social (belonging), self-esteem (internal, self-respect), and self-actualization (fullest potential). The higher levels represent social needs that are sometimes much harder to measure.
2. The teacher should add additional parameters to the discussion that define quality of life and standard of living. These can include type of government, perceived level of technology, housing types, transportation, manufacturing, information modes, sanitation and water quality, education, poverty level, and gross national product.
3. Students may provide examples of different cultures from their life experiences, travel, information from relatives or friends, pen pals, or social studies or language/culture classes.

Exploration

1. Working in small groups, students will select and examine a community, region, or nation based on its quality of life and standard of living.
2. The student groups will research the location and accumulate notes on a variety of criteria, technological and social.
3. The students will research alternatives and provide suggestions in a variety of areas.

Explanation

1. Students will provide basic information about the region they selected and describe why they selected it.
2. The teacher should provide examples for each criteria in a range of development possibilities.
3. The teacher will work with the groups to help them find information on their selected region, and provide resources that illustrate examples of possible alternatives.

Extension

1. Students can research and analyze information on a variety of criteria.
2. The student groups will research alternative technological solutions and suggest possibilities for improving quality of life for a variety of criteria.
3. Students will prepare and present their findings and suggestions.

Evaluation

Students knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for their group work, analysis, and presentation.

Additional Extension Activities

1. The students can make their presentations to local or regional community planning groups, or other civic groups.
2. The students can work with students in other schools, nationally or internationally, that are doing the same activity.
3. The students can develop international relationships with students and schools from other countries and exchange information and/or presentations over the Internet.

4. The students can collate and document their findings in a database containing additional student work from other classes, thus increasing the overall data collected for possible further research.

Laboratory-Classroom Preparation
Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations.

Tools/Materials/Equipment
Research materials and Web access
Calculators
Computers/software
Printers
Poster/sign maker

Laboratory-Classroom Safety and Conduct
Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class and show respect and appreciation for the efforts of others.

Assignment – Lesson 3-1
Design and Technology for Quality of Life

Select a Community

You will need to gather information about your local community or region. At least five groups will be chosen to examine different communities for comparison. Worksheets should be used for each. One group (Group A) will examine the local community based on the worksheet criteria for quality of life and standard of living. You may add criteria as a class for your own unique comparisons. The other four (or more) groups can be organized as follows:

Group B: Students in this group will examine another community in the region.
Group C: Students in this group will examine another community in the nation.
Group D: Students in this group will examine a community in another affluent country.
Group E: Students in this group will examine a community in a developing country.
Groups F: Students can be assigned to additional communities from any of the above.

Gathering Information

Students in each group will gather information and complete the following chart. Additional criteria may be added as a class if desired. Information will need to come from a variety of sources, each group will need to document its sources. If possible, interviews with people in the community may help. It may be helpful to discuss between groups how information was obtained so that a more complete comparison can be made. It is important to try to use information presented in other classes. Note: It may not be possible to gather all information for each community.

Presentation

Each group will develop a large-format chart or other graphic representation showing the details of their information gathering. These charts will be described to the class for each group, helping to develop a picture of the community studied. The presentation should be factual, not judgmental. Other class members may ask questions for clarification of any particular criteria. Following each group's presentation, the class will engage in an overall discussion on "quality of life," and "standard of living."

Analysis

Following the class discussion, the groups will meet to discuss ways the community can improve in each of the criteria. This information can be taken from the other groups' presentations, or from additional research. The table for each community will then be completed on the large format presentation. Finally, the class may want to present the overall presentation to a local community planning or other organizational group.

Assignment Worksheet – Lesson 3-1

Student Names:

Group:
Community:

Date:

Information Gathering

Use the chart below to gather your notes. Clearly enter all data and be sure to note your sources. Copy this sheet as needed for the entire group. You will use this information to develop your large format presentation.

Criteria	Notes
Background information: population, area, region, country	
Type of government	
Perceived level of technology	
Housing types	
Construction methods	
Transportation	
Manufacturing	
Information modes	
Sanitation and water quality	
Water quality	
Food production imports/exports	
Education/literacy levels	
Maslow's Hierarchy of needs	
Gross national product (regionalize)	
Poverty levels	
Other _____	
Other _____	
Other _____	

Presentation Ideas

(Leave room on your large format to add suggested improvements following the class presentations and analysis.)

Bibliography Notes

Analysis

Develop suggested improvements for as many criteria as possible. Use the chart below to develop your ideas. Carefully transfer them to your large-format presentation.

Criteria	Notes
Background information: population, area, region, country	
Type of government	
Perceived level of technology	
Housing types	
Construction methods	
Transportation	
Manufacturing	
Information modes	
Sanitation and water quality	
Water quality	
Food production imports/exports	
Education/literacy levels	
Maslow's Hierarchy of needs	
Gross national product (regionalize)	
Poverty levels	
Other _____	
Other _____	
Other _____	

Unit 3 – Lesson 2

Criteria for Safe and Ergonomic Design

Lesson Duration: Four (4) hours.

STL Standards
- Students will develop an understanding of the core concepts of technology. (2)
- Students will develop an understanding of the effects of technology on the environment. (5)
- Students will develop an understanding of the attributes of design. (8)
- Students will develop the abilities to apply the design process. (11)
- Students will develop the abilities to assess the impact of products and systems. (13)

STL Benchmarks
- Requirements involve the identification of criteria and constraints of a product or system and the determination of how they affect the final design and development. (2AA)
- The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. (5J)
- Humans devise technologies to reduce the negative consequences of other technologies. (5K)
- Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. (8K)
- Identify criteria and constraints and determine how these will affect the design process. (11N)
- Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment. (13K)

Learning Objectives
Upon completion of this lesson, students will be able to:
1. Select a technological device and analyze its use in terms of safety, health, and liability issues.
2. Evaluate a technological device for its ergonomic use.
3. Formulate suggestions for the improvement of a technological device based on ergonomic design criteria.
4. Use representations to model and interpret physical, social, and mathematical phenomena.
5. Recognize that in designing a device or product, thought must be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.
3-2A.
3-2B.
3-2C.
3-2D.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected of him/her.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Research/Analysis

Category	Below Target	At Target	Above Target
Variety of sources	Use very little or varied sources.	Used multiple sources with multiple perspectives.	Used many sources with a variety of view points.
Documentation	Little or inadequate documentation.	All sources documented and done so properly.	Documentation well developed and referenced.
Reflection	Analysis showed little effort.	Analysis thorough and well thought out.	Analysis exceptionally well thought out and showed keen insight.

Assessment Instrument – Presentation

Category	Below Target	At Target	Above Target
Organization	Presentation not well organized—hard to follow.	Presentation well organized and easy to follow.	Presentation exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation was creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.
Feedback	Audience did not participate in the presentation.	Audience was attentive to the presentation and participated when asked.	Audience extremely interested and asked many questions.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Research/Analysis	As per above			
Presentation	As per above			

Resource Materials

- Print-Based Sources
  - *Product Liability: In a Nutshell* (2004) Jerry Phillips
  - *Ergonomics for Beginners* (2001) Jan Dul & Bernard Weermeester
  - *Product Design & Development* (2003) Karl Ulrich & Steven Eppinger
- Audiovisual Materials
  - *Going Green* – discovering the "unfriendly" impact of your household on the environment (bullfrogfilms.com)
  - *NIOSH Pocket Guide to Chemical Hazards* (CD available from NIOSH – 1-800-35-NIOSH)
- Internet Sites (use key word ergonomics in Web search)
  - www.osha.gov/SLTC/ergonomics/ – Occupational Safety and Health Agency information on ergonomics

Purpose of Lesson

To examine technological products and evaluate them for potential hazards or other issues, and to make suggestions for improvements based on ergonomic principles.

Required Knowledge and/or Skills

Students should understand safety and ergonomic principles, and be able to use them to examine technological devices and make suggestions for improvement.

Lesson 3-2:

Engagement

1. The teacher may begin by discussing issues of safety in the use of technological devices or products. A review of design failures from Chapter 2, Lesson 3 may be helpful. Discuss various safety issues and who is at fault, such as baby furniture, toys, automobiles, tools, packaging, or even hot coffee.
2. Discuss anthropomorphic charts and how they are used. It may be helpful to generate some class averages and ranges for some simple measurements, such as height, arm length, foot size, etc. Discuss how this affects the designer when selecting criteria or constraints.
3. Provide several examples of tools or devices designed ergonomically. Students should be able to define ergonomics.

Exploration

1. Working in small groups, students will examine a technological device.
2. The students will research safety issues and ergonomic principles of design.
3. Students will research alternative designs that incorporate ergonomics and other safety principles.

Explanation

1. The teacher may provide examples of ergonomic devices and explain how and why they were developed.
2. The teacher will help the groups develop ergonomic criteria and constraints for future designs of a technological device.
3. The teacher will help each group research and develop alternative designs for its technological device.

Extension

1. Students groups will examine a device in terms of safety and potential product liability.
2. Students will examine a device and research possible improvements to enable the device to be developed ergonomically.
3. Students will develop and present their research.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, research/analysis, and presentation.

Additional Extension Activities

1. Classroom speakers can be used from a variety of areas, including physical therapists, health care workers, hardware owners, designers, etc.
2. Student work can be prominently displayed in the school for a period of time.
3. Students can present their findings to a local or regional health fair.
4. Student work can be collated and published graphically or electronically for distribution.

Laboratory-Classroom Preparation

Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations. Tools, devices toys, etc. (technological devices) should be accessible, along with measuring and other simple tools required for the analysis of the devices.

Tools/Materials/Equipment

Research materials and Web access
Computers/software
Tools and other technological devices for examination
Measuring and other simple tools for analysis of devices
Printers
Poster/sign maker

Laboratory-Classroom Safety and Conduct

Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class and show respect and appreciation for the efforts of others.

Assignment – Lesson 3-2
Criteria for Safe and Ergonomic Design

Selecting a Product or Device

Select a tool, household good, transportation device, building material, information device, toy, food product, packaging product, etc. based on recommendations from your instructor. Select a product based on its type or function, not on a particular brand. Provide a brief narrative or bulleted list of the product details and its intended uses. Additionally, select a product that has been well documented, or where information can be collected. Be sure to document your sources.

Safety/Liability Issues

Research the product. Identify any safety issues or product liabilities associated with the product. List those that have been identified, warned about, or implied in other studies. How have those problems been solved over time in previous products of the same type? Also consider safety issues concerned with repetitive use or use in the workplace. You can use the table on the worksheet to record your information. The worksheet table can be reproduced as needed.

Ergonomic Attributes/Suggested Improvements

What types of improvements could be made to this product to make it more ergonomic? Brainstorm ideas that will improve its interaction with humans, and its intended use. You may use descriptions, diagrams, sketches, drawings, models, prototypes, or other mediums to describe your improvements.

Presentation

Present your findings to the class. Be creative and complete in your analysis and presentation. Your instructor will provide you with possible presentation models available, based on your technology classroom. Options may include models/prototypes with detailed labels, PowerPoint (or similar) presentations, video presentations, or Web sites.

These students are working on a safe and ergonomic design.

Assignment Worksheet – Lesson 3-2

Student Name(s): **Product:**

Date:

Provide information on product and its intended use:

Safety and Liability

Use the matrix to record your findings. Be sure to document your sources. (Matrix can be reproduced as needed.)

	Intended Use	**Ergonomic/Workplace**
Safety Issues		
Liability Issues		

Ergonomic Suggestions

Record or sketch your ideas below. Use additional sheets if needed.

Presentation Suggestions

Unit 3 – Lesson 3

Lesson Title: Design Ethics and Product Liability

Lesson Duration: Four (4) hours.

STL Standards

- Students will develop an understanding of the core concepts of technology. (2)
- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop an understanding of the attributes of design. (8)
- Students will develop the abilities to apply the design process. (11)
- Students will develop the abilities to assess the impact of products and systems. (13)

STL Benchmarks

- Requirements involve the identification of criteria and constraints of a product or system and the determination of how they affect the final design and development. (2AA)
- Ethical considerations are important in the development, selection, and use of technology. (4J)
- Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. (8K)
- Identify criteria and constraints and determine how these will affect the design process. (11N)
- Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment. (13K)

Learning Objectives:

Upon completion of this lesson, students will be able to:

1. Describe the purpose of having a code of ethics for engineers and designers.
2. Examine the code of ethics for engineers and determine how it affects design criteria and constraints.
3. Discuss violations of design ethics and their consequences.
4. Describe product defects and provide examples.
5. List legislation enacted and organizations responsible for protecting the public.
6. Research and design solutions/alternatives in product safety scenarios.
7. Recognize and apply mathematics in contexts outside of mathematics.
8. Recognize that, when designing a device or process, thought must be given as to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.
3-3A.
3-3B.
3-3C.
3-3D.
3-3E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected of him/her.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Research

Category	Below Target	At Target	Above Target
Variety of Sources	Use very few or insufficiently varied sources.	Used multiple sources with multiple perspectives.	Used many sources with a variety of viewpoints.
Documentation	Little or inadequate documentation.	All sources documented and done so properly.	Documentation well developed and referenced.
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.

Assessment Instrument – Analysis/Presentation

Category	Below Target	At Target	Above Target
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented
Organization	Presentation not well organized—hard to follow.	Presentation well organized and easy to follow.	Presentation exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Research	As per above			
Analysis/Presentation	As per above			

Resource Materials

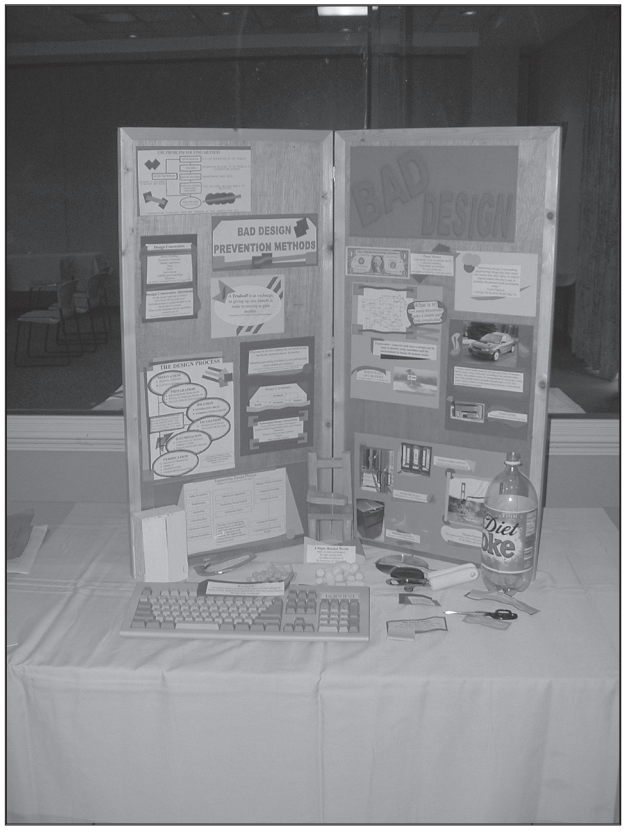
- Print-Based Sources
  - *Engineering by Design* (1999) Gerard Voland
  - *Ethical Issues in Engineering* (1991) Deborah Johnson
  - *Products Liability: In a Nutshell* (2004) Jerry Phillips
  - *Ethics for Citizenship in a Technological World* (2004) CTTE
- Audiovisual Materials
  - *Living Under the Cloud: The Chernobyl Disaster* (bullfrogfilms.com)
  - *In Our Own Backyard* – the first brush the US had with toxic waste at Love Canal (bullfrogfilms.com)
- Internet Sites
  - www.nspe.org – code of ethics from the National Society of Professional Engineers
  - www.niee.org/main.htm – National Institute for Engineering Ethics homepage
  - Most agencies/organizations listed in the lesson have Web sites where information can be found.

Purpose of Lesson

To identify ethical behaviors required for design and technology, and apply those to technological devices and the possible resulting product liabilities.

Required Knowledge and/or Skills

Students should be able apply the code of ethics to product design, examine products with respect to protective agencies or organizations, and make recommendations for solving design safety problems.



Student display shows bad designs.

Photo by Jason Hancock

Lesson 3-3:

Engagement

1. The teacher may begin by asking for a definition of ethics. The discussion should narrow the topic to engineering and design ethics. For example, doctors and lawyers have direct contact with their clients, so their ethical concerns are obvious. However, engineers and designers create things (bridges, buildings, products, etc.) and are thus not directly connected to their clients. How is this different, and what obligations do they have?
2. The teacher may want to describe certain historical instances of unethical behavior and the resulting consequences. Examples may include the Challenger disaster or others (see lesson references).
3. Students may discuss what types of actions can be used to prevent unethical behavior, such as government agencies, professional agencies, licensing professionals, legal acts, and litigation.

Exploration

1. Working in small groups, students will examine the engineer's code of ethics from the National Society of Professional Engineers (NSPE).
2. Student will discuss types of ethical violations and product liabilities from product defects.
3. Students will discuss types of legislation and agencies responsible for limiting harm to the public.
4. Student groups will examine a case scenario and research potential solutions.

Explanation

1. The teacher may want to review and lead a discussion on the engineer's code of ethics. It should be pointed out that having the code does not mean that the process is fail-safe, or that all situations will be addressed. However, the code provides guidelines for professionals, assures the public that engineering societies can regulate themselves, and allows engineering societies to protect members and punish offenders.
2. The teacher can provide examples of possible ethical violations. Discuss common types of violations, including: failing to protect the public; failing to provide all important information (in reports, statements, and testimonies); unethical disclosure of facts or information; performing work when unqualified to do so; expressing opinions or issuing statements without adequate knowledge or without disclosing interested parties that may have influence or may gain from a decision; or failing to act faithfully to a employer or client. It may be important to point out that the primary concern is for the safety and welfare of the public, which should outweigh any loyalty to the company (see II.1.a of the code).
3. The teacher should discuss sources of product defects, and provide some examples. Defects can be organized into 1) manufacturing defects—those that failed the manufacturers standards, 2) design defects—from inferior design or inadequate standards, and 3) warning defects—inadequate warnings for the user. Although beyond the scope of this course, a brief discussion of product liability law may be given (see lesson resource by Voland, pages 290-294).
4. The teacher should discuss agencies and organizations that have been created to protect the public. Agencies and organizations include: the Occupational Safety and Health Administration (OSHA), the Consumer Product Safety Commission (CPSC), the National Highway Transportation Safety Board (NHTSB), National Institute of Standards and Technology (NIST), Underwriters Laboratory (UL), Society of Automotive Engineers (SAE), Building Officials and Code Administrators International (publishes the BOCA national building codes), National Fire Protection Association (developed the national Fire Codes), Environmental Protection Agency (EPA), and many others.

5. The teacher may briefly describe legislative acts that have been created to protect the public, such as: Flammable Fabrics Act (1953), Refrigerator Safety Act (1956), National Traffic and Motor Vehicle Safety Act (1966), Federal Coal Mine Health and Safety Act (1969), Poison Protection Act (1970), Occupational Safety and Health Act (1970), National Environmental Policy Act (1969), Consumer Product Safety Act (1972), Technology Assessment Act (1972), and others.

Extension

1. Student groups will research an agency or organization whose responsibility is to protect the public, along with legislation created for that agency.
2. Students groups will research a design scenario case study, and evaluate possible solutions to the problem or part of the problem.
3. The student groups will give class presentations on both Numbers1and 2 above.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, research, and analysis/presentation.

Additional Extension Activities

1. Class speakers may present on issues of ethics, law, or product safety. They may be engineers, lawyers, or agency or organization members.
2. Student presentations may be given to local or regional civic groups or clubs.
3. Student presentations can be collated and presented graphically or through multimedia tools.
4. Students may pursue further research into product safety as a senior project.

Laboratory-Classroom Preparation

Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations. Tools, devices toys, etc. (technological devices) should be accessible.

Tools/Materials/Equipment

Research materials and Web access
Computers/software
Tools and other technological devices for examination
Printers
Poster/sign maker

Laboratory-Classroom Safety and Conduct

Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.

Explorations into new crops and new growing methods can create ethical issues.

Assignment – Lesson 3-3
Design Ethics and Product Liability

Part 1: Protection Agency or Organization

With the help of the teacher, select an agency or organization that is responsible in some way for the protection of the public's safety or health. Your group may select one discussed in class, or select another one of interest. Research the organization using the criteria listed on the worksheet. Additionally, research any legislation that was enacted to help the agency or organization, again using the criteria listed on the worksheet. Prepare a brief presentation of your findings.

Part 2: Scenario Research

Select a product design scenario and research potential product defects and/or liabilities. Research design alternatives or problem solutions to part or all of the problem. Select the product problem with the help of your instructor (a list of potential problems is given below). Through your research, provide details and analysis to the questions on the worksheet.

Possible Problem topics and Project Themes (from Voland, pages 505-510):

- Sports-related injuries caused by faulty equipment or facilities
- Tractor injuries or deaths
- Child restraints in automobiles
- School bus injuries or deaths
- Accidents involving emergency vehicles
- Forklift injuries
- Injuries related to toy use
- Injuries related to glass doors and/or windows
- Injuries from playground equipment
- Injuries from lawn mowers or chainsaws
- Railroad deaths and injuries
- Injuries in the home
- Injuries from stairs, ramps, landings, or floors
- Product defects from inadequate containers (e.g. egg cartons)
- Home damage from severe weather
- Improved bicycle design
- Environmentally sound cleaning systems
- Others

Presentations

Your group should prepare and present on both assignments: Part 1. Agency/organization and related legislature, and Part 2. Product details, problems, and possible solutions. The first presentation will be a brief 3-5 minute review of your findings. The second presentation should be creative, and should use tools available in your lab that may include graphic or computer applications.

Assignment Worksheet – Lesson 3-3

Student Names: **Date:**

PART 1: Agency/Organization Research

Research the following questions about your selected agency/organization and related legislation: (use additional sheets if necessary)

1. When was the agency/organization created?

2. What is the purpose of the agency or organization?

3. Was there a specific incident or issue that led to the agency or organization to be created?

4. How does the agency/organization protect the safety or health of the public?

5. Are there specific technology devices, products, or processes protected by the agency/organization?

6. What legislation helps the agency or organization?

7. When was the legislation passed and, briefly, what does it protect?

Presentation Outline

Use the space below to organize and develop an outline for a brief 3-5 minute presentation to the class:

PART 2: Design Problem Scenario

Student Names: **Date:**

Problem selected:

Problem Statement: (briefly describe the problem)
Your problem statement should come from researching the following questions:

1. What types of injuries or fatalities have occurred from your design scenario, and how often do they happen?

2. Are there product or process defects, and what types?

Research
Research the following related to your scenario:

3. Have any of the engineers' codes of ethics been violated or not fully complied with?

4. List any agencies or organizations or legislative acts that are relevant to this product scenario.

5. What types of alternatives are available?

6. What solutions seem feasible to part or all of the problem?

Analysis/Presentation

Develop one or more possible solutions to part, or all, of the problem. Use notes, sketches, pictures, drawings, or other mediums to develop your ideas. Document all of your sources as well as your design work. Your presentation should include a statement of the problem, related information on ethics, defects and/or agencies and legislation, and a detailed account of your proposed solution(s).

Unit 3 – Lesson 4

Modeling Monitoring Technology

Lesson Duration: Six (6) hours.

STL Standards
- Students will develop an understanding of the core concepts of technology. (2)
- Students will develop an understanding of the effects of technology on the environment. (5)

STL Benchmarks
- Requirements involve the identification of criteria and constraints of a product or system and the determination of how they affect the final design and development. (2AA)
- With the aid of technology, various aspects of the environment can be monitored to provide information for monitoring. (5I)
- The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. (5J)
- Humans devise technologies to reduce the negative consequences of other technologies. (5K)
- Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment. (5L)

Learning Objectives
Upon completion of this lesson, students will be able to:
1. Describe technological activities that impose consequences on the environment.
2. Recognize and describe problems with air, water, soils, and other environmental qualities.
3. Evaluate monitoring technologies and their effectiveness in preventing technological issues.
4. Research and model technological monitoring devices and processes used to protect the environment.
5. Understand and use ratios and proportions to represent quantitative relationships.
6. Recognize and apply mathematics in contexts outside of mathematics.
7. Use representations to model and interpret physical, social, and mathematical phenomena.
8. Recognize that technological problems often create a demand for new scientific knowledge, and new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research.
9. Recognize that human beings are part of the earth's ecosystem, and that their activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.
10. Understand that waste management includes considerations of quantity, safety, degradability, and cost, and requires social and technological innovations because waste-disposal problems are political and economic as well as technical.
11. Recognize that, in deciding among design alternatives, a major question is who will receive the benefits and who will bear the costs.

Student Assessment Tools and/or Methods
Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.
3-4A.
3-4B.
3-4C.
3-4D.
3-4E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected of him/her.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Research

Category	Below Target	At Target	Above Target
Variety of Sources	Used very few or insufficiently varied sources.	Used multiple sources with multiple perspectives.	Used many sources with a variety of viewpoints.
Documentation	Little or inadequate documentation.	All sources documented and done so properly.	Documentation was well developed and referenced
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.

Assessment Instrument – Model/Presentation

Category	Below Target	At Target	Above Target
Model Development	Model poorly made and not representative of the technology.	Model well crafted and represents the technology accurately.	Model very well crafted and very representative of the technology.
Model Details	Details missing or misrepresented.	Many details of the technology easily seen.	Model extremely detailed and accurate.
Organization	Presentation not well organized—hard to follow.	Presentation well organized and easy to follow.	Presentation exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Research	As per above			
Model/Presentation	As per above			

Resource Materials

- Print-Based Sources
  Worldwatch Institute has various publications (see Web site below)
- Audiovisual Materials
  Kilowatts from Cowpies (bullfrogfilms.com)
  Garbage into Gold (libraryvideo.com)
  Flush Toilet, Goodbye (bullfrogfilms.com)
  Natural Waste Water Treatment (bullfrogfilms.com)
- Internet Sites
  www.epa.gov/ttn/amtic/ – Environmental Protection Agency's list of monitoring programs
  www.epa.gov/etv/centers/center1.html – EPA's environmental technology verification program details
  www.worldwatch.org/ – Worldwatch Institute homepage

Purpose of Lesson

To examine technology designed to monitor processes to eliminate or reduce technological issues with the environment.

Required Knowledge and/or Skills

Students should have the ability to research a variety of environmental problems related to technology, and research and model applications of monitoring technologies required to lessen the impacts of technology on the environment.

Lesson 3-4:

Engagement:

1. The teacher should lead a discussion on environmental problems or issues related to technology. The discussion should include problems with the air, atmosphere, water quality, rain/snow acidity, ocean health, soil condition and run-of, effects on plants and animals, toxicity levels in plants and animals, degradation of structures, and other issues.
2. Students should generate a list of causes, which may be direct or indirect. Examples can be given to students based on firsthand experience, local or regional problems, articles or stories in journals, papers, or the media, discussions from other classes, or other sources.
3. Historical examples of environmental disasters can be discussed, with implications to current trends of growth of population and use of technology (explored in Chapter 2, Lesson 1).

Exploration

1. Working in small groups, students will research a current environmental problem or issue.
2. The student groups will examine current scientific data and project future increases based on current trends.
3. Student groups will examine monitoring devices or processes that address the issue they are researching, evaluating them on a variety of criteria.

Explanation

1. The severity of environmental problems should be discussed. It may be helpful to point out that problems may not be at critical stages yet, may present problems in the future based on current or future trends, and/or may be addressed too late to reverse the problem.
2. The teacher may use an example to demonstrate how different groups may conclude different outcomes of the same problem, often based on the same data. There are uncertainties to

predicting future consequences, but there are also severe consequences for ignoring problems or issues.
3. Discussions of technologies that contribute to environmental problems or issues should include: burning fossil fuels, enriching and disposing of uranium fuels, mining or drilling for coal and oil, moving energy resources, fertilizing soils, reducing forests or trees, monoculture of crops in large amounts, burning wood, waste disposal options, chemical production, use of paints, solvents, and other chemicals in industry, use of water for industrial processes, livestock production farms, use of water for irrigation projects, diverting water for energy production, use of plastics and foams in packaging, lack of recycling efforts, dumping wastes in the ocean, release of greenhouse gases, and others.
4. The teacher will work with groups to help them research their topics, organize and analyze their information, and develop technology-monitoring models.

Extension:
1. Student groups will research an environmental problem or issue related to the use of technology.
2. Student groups will research and analyze potential environmental impacts of their issue.
3. Student groups will evaluate options for technology-monitoring devices or processes to protect the environment.
4. Student groups will model a monitoring device or technique and present their overall research.

Evaluation:
Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, research, and model/presentation.

Additional Extension Activities
1. Guest speakers to the class may include engineers, environmental protection agents, researchers, or others in fields related to the lesson.
2. Student work may be presented to environmental groups or other local or regional clubs or organizations.
3. Student work can be displayed prominently in the school for a period of time.
4. Student work and presentations can be collated graphically or electronically for distribution.

Laboratory-Classroom Preparation
Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations. They should have workbench space and hand tools and materials available for modeling monitoring technology devices and techniques.

Tools/Materials/Equipment

Research materials and Web access	Computers/software	Modeling materials and tools
Printers	Poster/sign maker	

Laboratory-Classroom Safety and Conduct
Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.

Assignment – Lesson 3-4
Modeling Monitoring Technology

Environmental Problem /Issue Selection

Student groups, with help from the instructor, should select an environmental problem or issue related to the use of technology. Groups may select a problem discussed in class or select another problem or issue. Research should include the nature of the problem, technological causes, potential current risks, perceived future risks, and risks associated with ignoring the problem. Perceived future risks may need to be extrapolated mathematically from current trends.

Research Monitoring Technologies

Research possible current or future monitoring technologies that address the environmental problem you are researching. Find out how they work, by how much they may relieve the problem, economic costs (plus who benefits and who pays), other social issues involved with their implementation (such as politics), regulations or policies that may help or hinder their development or application, actions that may help it become accepted, and other related issues. The table on the worksheet will help you gather and organize your information.

Monitoring Model

Select one of the options you have researched that appears to help relieve the problem and seems like it will be adopted. Develop a model of the technology and research how it works. The model can describe a specific technological device or process. The scaled model can be scaled, detailed, or developed in cross section to show its operation. Employ a method of listing parts and their function.

Presentation

Develop a presentation of your research findings and your technological monitoring device or process. Describe the problem, how the problem may get worse, possible solutions, and your model depicting a solution that appears reliable, functional, and acceptable.

Assignment Worksheet – Lesson 3-4

Student Names: **Date:**

Environmental Problem:

Research: (use additional paper as needed)

Determine or estimate the following:

1. Nature of the problem:
2. List technological causes:
3. List potential current risks:
4. Estimate perceived future risks:
5. Determine risks associated with ignoring the problem:

Complete the following table in as much detail as possible for various monitoring devices or pro-

	Technology Option 1	Technology Option 2	Technology Option 3	Technology Option 4
Description				
How it works				
How it may help relieve the problem				
Economic costs (who pays and who benefits)				
Social issues that may hinder its application				

	Technology Option 1	Technology Option 2	Technology Option 3	Technology Option 4
Regulations or policies that may help or hinder				
Actions that may help develop it (such as legislation)				
Other factors identified				

Modeling Ideas

Document your brainstorming and developmental ideas below on your monitoring model. Describe how you will display your model and relate its function and operation.

Presentation Ideas

Develop and outline below your presentation for the class:

Unit 4
Addressing Technological Issues

Engineering By Design
A National Model for Standards-Based Programs

Unit 4: Addressing Technological Issues

STL Standards

- Students will develop an understanding of the characteristics and scope of technology. (1)
- Students will develop an understanding of the core concepts of technology. (2)
- Students will develop an understanding of the relationships among technologies and the connections between technology and other fields. (3)
- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop an understanding of the effects of technology on the environment. (5)
- Students will develop an understanding of the role of society in the development and use of technology. (6)
- Students will develop the abilities to apply the design process. (11)
- Students will develop an understanding of and be able to select and use information and communication technologies. (17)

STL Benchmarks

- The nature and development of technological knowledge and processes are functions of the setting. (1J)
- Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. (2Z)
- Requirements involve the identification of criteria and constraints of a product or system and the determination of how they affect the final design and development. (2AA)
- Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. (3H)
- Technological ideas are sometimes protected through a process of patenting. (3I)
- Making decisions about technology involves weighing the trade-offs between the positive and negative effects. (4I)
- Ethical considerations are important in the development, selection, and use of technology. (4J)
- The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. (5J)
- Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment. (5L)
- The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. (6I)
- Identify criteria and constraints and determine how these will affect the design process. (11N)
- Develop and produce a product or system using the design process. (11Q)
- Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. (17N)

Mathematics Standards

1Q Understand and use ratios and proportions to represent quantitative relationships.

12M Make decisions about units and scales that are appropriate for problem situations involving measurement.

13Q Solve problems involving scale factors, using ratio and proportion.

20B Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.
21C Use representations to model and interpret physical, social, and mathematical phenomena.

Science Standards

3P Progress in science and invention depends heavily on what else is happening in society, and history often depends on scientific and technological developments.
7K Technological problems often create a demand for new scientific knowledge, and new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research.
8J In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.
8K The value of any given technology may be different for different groups of people and at different points in time.
8M Risk analysis is used to minimize the likelihood of unwanted side effects of a new technology. The public perception of risk may depend, however, on psychological factors as well as scientific ones.
9Q Social and economic forces strongly influence which technologies will be developed and used. Which will prevail is affected by many factors, such as personal values, consumer acceptance, patent laws, the availability of risk capital, the federal budget, local and national regulations, media attention, economic competition, and tax incentives.
9U Human inventiveness has brought new risks as well as improvements to human existence.
21L Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.
24N Written records and photographic and electronic devices enable human beings to share, compile, use, and misuse great amounts of information and misinformation. No other species uses such technologies.
33K In deciding among alternatives, a major question is who will receive the benefits and who (not necessarily the same people) will bear the costs.
38N Waste management includes considerations of quantity, safety, degradability, and cost. It requires social and technological innovations, because waste-disposal problems are political and economic as well as technical.
58J Understanding how things work and designing solutions to problems of almost any kind can be facilitated by systems analysis. In defining a system, it is important to specify its boundaries and subsystems, indicate its relation to other systems, and identify what its input and output are expected to be.
62H View science and technology thoughtfully, being neither categorically antagonistic nor uncritically positive.
66N Be aware, when considering claims, that when people try to prove a point, they may select only the data that support it and ignore any that would contradict it.

Big Idea

Developing solutions to address human needs or wants, requires certain practices, policies, and protections to minimize technological issues.

Unit 4 Objectives

At the completion of this unit, students will be able to:

- Design and prototype technical devices that minimize technological issues from inappropriate technology.
- Apply solutions to technological problems that lead to the conservation of energy, water, and other resources.
- Examine the use of information, policies, and protections to minimize issues from the development and transfer of technologies.
- Evaluate how acquiring, applying, and protecting technical knowledge reduces technological issues.

Assessment

Assessment for each lesson includes a quiz, and rubrics will be used for group work and/or parts of the research, analysis, and presentation.

Teacher Preparation

Teacher preparation for this unit should include:

- Gather references, or make available examples of historical changes and technological innovations and inventions. As students discover good references, Web sites, films/documentaries, local historical sites, etc., develop a database.
- Research historical events to examine their technological and social interactions. Develop a list of potential topics for the students.
- Discuss with other teachers what students are studying in their classes, including history, economics, social studies, science, mathematics, and other technology classes, and how those concepts are related to technological issues.
- Gather examples of technological and/or social issues that are current from news articles or media presentations.
- Review teaching methodologies used in Lessons 1-4.
- Make copies of the assignments (one page, double-sided if need be) and the worksheets (one page, double-sided if need be) for each student or group.

Unit 4 – Lesson 1

Appropriate Technology Design

Lesson Duration: Twelve (12) hours.

STL Standards

- Students will develop an understanding of the characteristics and scope of technology. (1)
- Students will develop an understanding of the core concepts of technology. (2)
- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop an understanding of the effects of technology on the environment. (5)
- Students will develop the abilities to apply the design process. (11)
- Students will develop an understanding of and be able to select and use information and communication technologies. (17)

STL Benchmarks

- The nature and development of technological knowledge and processes are functions of the setting. (1J)
- Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. (2Z)
- Requirements involve the identification of criteria and constraints of a product or system and the determination of how they affect the final design and development. (2AA)
- Making decisions about technology involves weighing the trade-offs between the positive and negative effects. (4I)
- The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. (5J)
- Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment. (5L).
- Identify criteria and constraints and determine how these will affect the design process. (11N)
- Develop and produce a product or system using the design process. (11Q)
- Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. (17N)

Learning Objectives:

Upon completion of this lesson, students will be able to:

1. Identify and define criteria for appropriate technology design.
2. Identify specific people/places for an appropriate technology application.
3. Establish appropriate technology criteria and constraints for a technological development.
4. Research, design, model/prototype, test, and analyze an appropriate technology device or process.
5. Evaluate the design prototype against the established criteria and constraints.
6. Document design work as a communication tool.
7. Make decisions about units and scales that are appropriate for problem situations involving measurement.
8. Solve problems involving scale factors, using ratio and proportion.
9. Recognize and apply mathematics in contexts outside of mathematics.
10. Recognize that, in designing a device or process, thought should be given to how it will be

manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.
11. Realize that the value of any given technology may be different for different groups of people and at different points in time.
12. Recognize that, in deciding among design alternatives, a major question is who will receive the benefits and who will bear the costs.
13. Understand how things work, and design solutions to problems with the use of systems analysis.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.
4-1A.
4-1B.
4-1C.
4-1D.
4-1E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more Routinely offered useful ideas
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected of him/her.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Research/Criteria

Category	Below Target	At Target	Above Target
Variety of Sources	Use very little or varied sources.	Used multiple sources with multiple perspectives.	Used many sources with a variety of viewpoints.
Documentation	Little or inadequate documentation.	All sources documented and done so properly.	Documentation well developed and referenced.
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.
Criteria	Few criteria established and often inappropriate.	Many criteria established that are applicable to the problem.	Many levels of criteria and extremely useful for the design problem.

Assessment Instrument – Model/Prototype

Category	Below Target	At Target	Above Target
Development	Unsafe practices used in the lab, not considerate of others around.	Works safely in the lab, has respect for others work.	Works safely in the lab, willing to help others in the lab.
Model Development	Model poorly made and is not representative of the technology.	Model well crafted and represents the technology accurately.	Model very well crafted and is very representative of the technology.
Model Details	Details missing or misrepresented, does not meet the design criteria.	Many details of the technology are easily seen, meets the design criteria.	Model extremely detailed and accurate, meets all design criteria and constraints.

Assessment Instrument – Presentation/Documentation

Category	Below Target	At Target	Above Target
Organization	Presentation not well organized—hard to follow.	Presentation well organized and easy to follow.	Presentation exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.
Document Tool	Document poorly organized and difficult to follow or understand.	Document well organized and is representation of the design project.	Document very well organized and creative, and closely fits a professional job.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Research/Criteria	As per above			
Model/Prototype	As per above			
Presentation/ Documentation	As per above			

Resource Materials

- Print-Based Sources
  - *Solar Living Source Book* (12 ed. 2005) John Schaeffer
  - *Field Guide of Appropriate Technology* (2003) Barrett Hazeltine (ed)
  - *The Appropriate Technology Reader* (1985) Marilyn Carr
  - *Appropriate Technology for Sustainable Living* (2001) CTTE
- Audiovisual Materials
  - *No Spare Parts* – ingenious recycling of used car parts in Ghana (bullfrogfilms.com)
  - *Rammed Earth Construction* (bullfrogfilms.com)
  - *Peanuts* – a hand-operated peanut sheller makes a difference in the lives of villagers around the world (bullfrogfilms.com)

- Internet Sites
  www.ncat.org/ – National Center for Appropriate Technology homepage
  www.itdg.org/ – Intermediate Technology Development Group homepage

Purpose of Lesson
To design appropriate technology models or prototypes using established criteria.

Required Knowledge and/or Skills
Students should understand the tenets of appropriate technology, apply them to develop criteria and constraints to a design problem, and to prototype and evaluate a design proposal.

Lesson 4-1:

Engagement
1. The teacher may begin by discussing the appropriate technology movement, a worldwide movement to design products, devices, processes, and technology infrastructures that are appropriate for those who use them. Examples can be provided, both historical and current, and for appropriate and inappropriate technologies. Appropriate technology implies that there are inappropriate technologies. For instance, during the green revolution of the 1960s, industrialized countries provided tractors to developing countries to help them produce more food. The transfer failed, because the majority of poor farmers could not afford them, fuels were not available, they did not know how to maintain them, and they displaced many employed people.
2. It should be explained that the appropriate technology movement was conceived to address the problems of failed technology transfers of the past as well as many related social issues. Simply put, appropriate technology attempts to develop the technology based on the people and situation in which it is placed.

Exploration
1. Working in small groups, students will examine case studies of appropriate technology transfer cases. They will identify criteria and constraints that were used, or should have been used to make the transfer a success.
2. Student groups will research an appropriate technology application.
3. Students groups will identify and evaluate potential solutions to an appropriate technology application.

Explanation
1. Students will discuss their transfer cases and develop a list of criteria and constraints that model the appropriate technology movement.
2. The teacher will lead a discussion of appropriate technology examples that reflect applications that may be usable locally, regionally, nationally, or internationally.
3. The teacher will work with groups to identify and research their appropriate technology design problem.
4. The teacher will work with groups to develop models or prototypes of an appropriate technology based on the criteria and application.

Extension
1. Students will review appropriate technology case studies and evaluate their effectiveness.
2. Student groups will identify, define, and research an appropriate technology design application.

3. Students will develop models or prototypes of an appropriate technology device or process.
4. Student groups will organize and present their findings.
5. Student groups will document their design work as a communication tool.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, research/criteria, model/prototype, and presentation.

Additional Extension Activities

1. Student groups may communicate their designs to other regions or countries using the Internet.
2. The students can collate their designs and develop an appropriate technology catalog of designs.
3. Develop methods of patenting or protecting their appropriate technology device (see Lesson 4 in this chapter).
4. Student work should be prominently displayed in the school for a period of time.
5. Student designs and presentations can be collated and presented graphically, using computer media, or cataloged on a Web site.

Laboratory-Classroom Preparation

Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations. They should have laboratory space, hand tools and materials, and prototyping machines/equipment available for modeling/prototyping appropriate technology devices or processes.

Tools/Materials/Equipment

Research materials and Web access
Design journals
Computers/software
Modeling/prototyping materials, machines, equipment and tools
Presentation tools and software
Printers
Poster/sign maker

Laboratory-Classroom Safety and Conduct

Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class and show respect and appreciation for the efforts of others.

Assignment – Lesson 4-1
Appropriate Technology Design

Selecting an Appropriate Technology

Individually, or in small groups, determine a technological problem that would benefit from an appropriate technology solution. The problem could be local, regional, national, or international. This will take some research; you may need to gather a lot of possibilities before you settle on a particular problem. A few examples of areas that lend themselves to appropriate technology (AT) are listed below, and are categorized:

Information: marketing a local product or device, health care brochures for a specific audience, local newsletter/publication on AT available to community, print, radio, or video showing AT application or directions

Manufacturing: local production, developing energy sources for production, developing local building materials, food production (dryers, grinders, etc.)

Transportation: moving small goods, moving water, moving small groups of people, moving people with special needs

Construction: developing local building techniques, using local building materials, basic housing, community structures, playground designs using recycled materials, solar or renewable buildings, conservation devices

Biotechnology and Agriculture: sanitation methods such as composting toilets, supplying basic dietary needs, acquiring and administering new medicines and vaccinations, natural gardens and pest control

Technology and Design: water treatment devices, specialty tool design, pedal-powered devices, alternative energy designs, solar cooking devices, recycled products

Research

Research the problem and develop an appropriate design statement. Gather ideas on similar devices that may be used or modified to possibly solve the problem. Develop a list of criteria and constraints, based on technological issues and social issues of the intended user of the technology. Brainstorm and document as many possible solutions as you or your group can think of. Do not eliminate or ridicule any ideas in the brainstorming stage; a silly idea may lead to another good idea. The more ideas you have to choose from, the better chance you will have of discovering a good solution.

Based on your criteria and constraints, select one of your possible solutions that appears to best meet your design statement. Develop and produce a model or working prototype of the solution. Your final solution will vary depending on the technology lab you have at your school. You may need to get help from local engineers, technicians, or craftspeople depending on the sophistication of your prototype.

Analysis

Present your design to the class or local community group. Evaluate your solution. Does the design follow the goals of appropriate technology? Does the solution solve the original design problem? Did the problem statement change during the design? Did the design fit your criteria and stay within your constraints? Did the technological solution meet the needs of its intended users? What types of changes did you make during the design process, and why? What types of modifications would you do if you were allowed additional time to redesign the technology?

If you have additional time in your class or on your own, make the necessary changes and re-evaluate your solution.

Presentation/Documentation

Your presentation should include the final project as well as all documents you developed during the design process. Thumbnail sketches (brainstorming), idea generations, notes, drawings, photos, and all other documentation should be included in some type of journal. As you present, discuss problems you encountered and how you solved each of them.

Using recycled materials to design a power washer.

Assignment Worksheet – Lesson 4-1

Journal Entries

Student Name(s): **Date:**

Brainstorming/Ideation

Using a journal format, document your process of selecting an application that would benefit from an appropriate technology solution. Include information that includes the following:

Background – perceived need, people involved, location, types of problems, both social and technological

Possible solutions – examples of current technology, sketches, drawings, photos, notes

The Problem

Develop and place in your journal a detailed problem statement that you or your group will use for the remainder of the design process.

Develop a list of criteria that will guide your design and place it in your journal. Include information on the people and situations for which the technology will be designed. Include appropriate technology goals and criteria.

Develop a list of constraints that will guide your design and place it in your journal. Constraints may be technological, economical, or may reflect other social issues.

Research

Research the problem thoroughly. Document all your information and sources in your journal. Develop as many solutions to the problem as possible. Document your potential solutions using descriptions, sketches, drawings, photos, or other means.

The Solution

Review your brainstorm ideas. Select one solution that appears as though it will best solve your design problem, with appropriate criteria and constraints. Develop a model or working prototype of your solution. You may need to get help from local engineers, technicians, or craftspeople depending on the sophistication of your prototype. Once complete, develop detailed and annotated

drawings of your solution to enable others to replicate your design. Include them in your journal.

Analysis

Individually, or as a group, analyze your design. In your journal, develop responses to the following questions. Add additional analysis as needed based on your solution and the design process.

1. Does the design follow the goals of appropriate technology?

2. Does the solution solve the original design problem?

3. Did the problem statement change during the design? Did the design fit your criteria and stay within your constraints?

4. Did the technological solution meet the needs of its intended users?

5. What types of changes did you make during the design process, and why?

6. What types of modifications would you do if you were given additional time to redesign the technology?

7. Describe the design process you were involved with—how could this process help you with future design problems?

Presentation

Present your solution to the class or community group. Discuss your problem statement, criteria and constraints, problems encountered, solutions developed, analysis, and your solution. Explain in detail your model or prototype.

Unit 4 – Lesson 2

Model City Design Based on Recycling and Green Products

Lesson Duration: Twelve (12) hours.

STL Standards

- Students will develop an understanding of the core concepts of technology. (2)
- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop an understanding of the effects of technology on the environment. (5)
- Students will develop the abilities to apply the design process. (11)
- Students will develop an understanding of and be able to select and use information and communication technologies. (17)

STL Benchmarks

- Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. (2Z)
- Requirements involve the identification of criteria and constraints of a product or system and the determination of how they affect the final design and development. (2AA)
- Making decisions about technology involves weighing the trade-offs between the positive and negative effects. (4I)
- The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. (5J)
- Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment. (5L).
- Identify criteria and constraints and determine how these will affect the design process. (11N)
- Develop and produce a product or system using the design process. (11Q)
- Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. (17N)

Learning Objectives

Upon completion of this lesson, students will be able to:

1. Understand the concept of human scale as it relates to a small city.
2. Define the term green product and provide examples in a variety of technological areas.
3. Research areas of city planning in small groups, working within a larger planning group.
4. Research options of city planning that emphasize human scale, recycling, green products, and environmentally sound practices.
5. Document the class design solution using communication tools.
6. Develop a scaled model city based on small group research and overall planning.
7. Understand and use ratios and proportions to represent quantitative relationships.
8. Make decisions about units and scales that are appropriate for problem situations involving measurement.
9. Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.
10. Recognize and apply mathematics in contexts outside of mathematics.
11. Recognize that social and economic forces strongly influence which technologies will be developed and used.

12. Recognize that humans are part of the earth's ecosystems, and that human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.
13. Recognize that waste management includes considerations of quantity, safety, degradability, and cost.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.

4-2A.
4-2B.
4-2C.
4-2D.
4-2E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected of him/her.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Research

Category	Below Target	At Target	Above Target
Variety of Sources	Use very few or insufficiently varied sources.	Used multiple sources with multiple perspectives.	Used many sources with a variety of viewpoints.
Documentation	Little or inadequate documentation.	All sources documented and done so properly.	Documentation well developed and referenced.
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.

Assessment Instrument – Group Solutions

Category	Below Target	At Target	Above Target
Thoroughness	Very few ideas proposed or inadequate ideas.	Many ideas proposed in all areas of the group.	Extensive number of ideas proposed, with much detail.
Integration	Solutions proposed not integrated very well with the ideas of the remaining groups.	Ideas well integrated with most of the other groups.	Ideas proposed integrate very well with all of the other groups.
Appropriateness	Solutions do not match well with recycling or green ideas.	Solutions match well with recycling and green ideas.	Solutions are very well suited to recycling and green concepts.

Assessment Instrument – Presentation

Category	Below Target	At Target	Above Target
Organization	Presentation not well organized—hard to follow.	Presentation well organized and easy to follow.	Presentation exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.
Feedback	Audience did not participate in the presentation.	Audience attentive to the presentation and participated when asked.	Audience was extremely interested and asked many questions.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Research	As per above			
Group Solutions	As per above			
Presentation	As per above			

Resource Materials

- Print-Based Sources
  - *Human Scale* (1980) Kirkpatrick Sale
  - *Solar Living Source Book* (12 ed. 2005) John Schaeffer
- Audiovisual Materials
  - *Kilowatt Ours: Energy Conservation and Renewables* (videoproject.com)
  - *Cities* – is "sustainable cities" an oxymoron or can they be made to work (bullfrogfilms.com)
  - *Home: Green Technology and Innovative Design Save Energy* (bullfrogfilms.com)
  - *Design With The Sun* – tour of passive solar homes (bullfrogfilms.com)
- Internet Sites (use green products or recycling for Web search)
  - www.epa.gov/greenbuilding/ – EPS's green building information
  - www.epa.gov/recyclecity/ – EPA's information on city recycling
  - www.nrc-recycle.org/ – National Recycling Coalition organization homepage
  - www.bigcities.govt.nz/ – quality of life study in new Zealand cities

Purpose of Lesson

To simulate the development of a model city based on concepts of human scale, recycling, green products, and environmentally/ecologically sound principles.

Required Knowledge and/or Skills

Students should be able to research in small groups, interact with the larger group, and develop model components of an environmentally-sound city design.

Student project using bicycle power as an alternative transportation for a model city.

Lesson 4-2:

Engagement

1. The teacher may begin by quoting the annual "best city to live in" poll. Compare the best and worst cities to a city near the schools region. Why did the best cities get the awards, discuss some of the criteria.
2. The teacher may ask the students: What is the optimal size of a city? Discuss the concept of scale. Our modern industrial model again has us believe that bigger is better. A manufacturing plant, which has invested in tools and equipment, must make enough goods to make the investment pay for itself. However, too many goods may be wasteful. This has created a market of consumerism—we are constantly persuaded to buy products or services we may not need. It fact, the very concept of "quality of life" in our modern society is often related to how much we consume.
3. Discuss other issues of scale, including the size of cities, governments, communities, nations and so forth. How big is the optimal city? In other words, when does an increase in size cost more in services and dollars? It has been demonstrated that when cities, governments, etc. get too large, more people are needed to manage them, creating an increasingly bureaucratic and inefficient system.

Exploration

1. Students will review quality of life and standards of living parameters (see Chapter 3, Lesson 1).
2. Working in small groups, students will examine sections of city planning and management.
3. The student groups will research and evaluate green products, recycling, alternatives, and environmentally sound practices of city planning and management.
4. Students will work in small groups and coordinate with the larger class to develop, plan, and model a small city.

Explanation

1. The teacher may explain the roles of various entities and functions of a city. These may include regional planning, transportation, business and industry, public works (phone and electric, access to information services, sanitation, water, and regional needs), construction (buildings, both residential and business), parks and leisure (entertainment, travel, tourism, etc.). Students can bring examples into the discussion based on information from their other classes.
2. The teacher should lead a discussion on recycling, green products, or green buildings, and provide local or regional examples.
3. The teacher should suggest examples of alternative technologies for buildings, transportation, manufacturing, waste disposal, and other technologies important to the function and management of a city.
4. The teacher will work with individual groups to help them research and evaluate alternatives for their part of the larger project. The teacher will also need to work closely with the group that is coordinating all of the planning efforts.
5. The teacher should provide journals and stress the importance of students documenting all of their research.

Extension

1. Students will work in small groups to plan their section of a model city, working closely with the other groups.
2. Student groups will research and evaluate alternative technologies for their section of the project.
3. Through inter-group interaction, students will develop scaled models of components from their part of the project, and determine where they will be placed on the overall project.
4. The class will present and explain its finished model city design project.
5. Students will document their work using communication tools, written, graphic, and video.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, research, group solutions, and presentation.

Additional Extension Activities

1. Students may use field trips to visit a local recycling center, local green buildings, or a manufacturing plant that has minimized and accounted for most of its waste.
2. Students may wish to use simulation software, such as Sim City©, to get additional exposure to planning, operating, and maintaining a city (see Chapter 5, Lesson 2).
3. Students may wish to expand on this assignment and make it multidisciplinary throughout the school.
4. Students may design and construct an outdoor learning center for their elementary school using mostly recycled products.
5. Students may wish to present the model to local or regional planning groups or committees.
6. Students can document their work, finished product, and the design stages, using a video format that could be shown on local television.

Laboratory-Classroom Preparation

Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations. They should have laboratory space, hand tools and materials, and prototyping machines/equipment available for modeling/prototyping a scaled city, as well as space for the final city layout.

Tools/Materials/Equipment

Research materials and Web access
Computers/software
Student journals
Modeling/prototyping materials, machines, equipment and tools
Scaled models of houses, cars, buildings, etc.
Printers
Poster/sign maker
Multimedia/graphic tools

Laboratory-Classroom Safety and Conduct

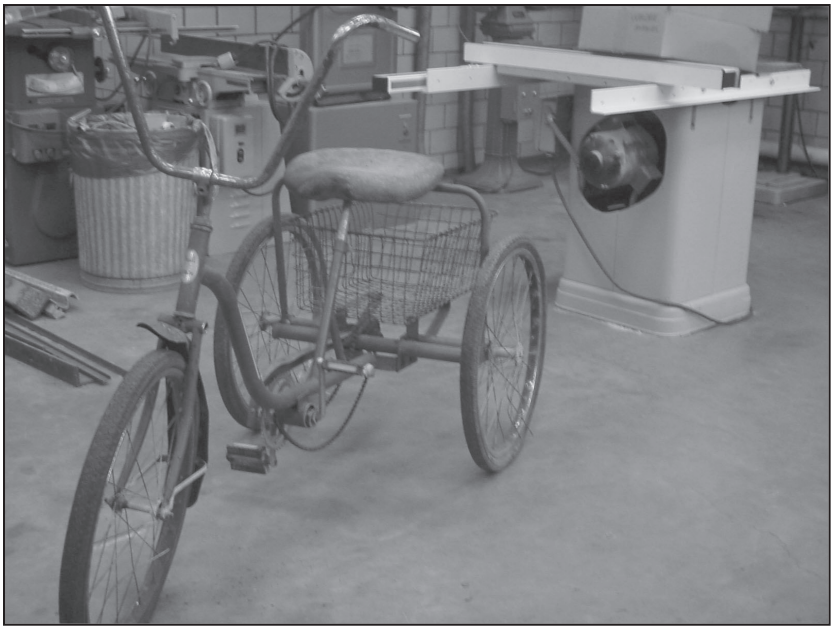
Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.

Assignment – Lesson 4-2
Model City Design Based on Recycling and Green Products

Background

Many scholars who have looked at human history and current trends have concluded that the optimal city or community is somewhere between 10,000 and 50,000 people. This allows people to socialize and get the services they need on a human scale. Above this number, services cost more, get more complex, and require more resources to manage and control. This is evident from the annual report on the best cities to live in, which are generally smaller in scale. Cities have grown in various regions for a variety of reasons: close to transportation, close to energy sources, climate and environment, business opportunities, etc. If you were planning a new city or community from scratch, what would you include?



The Problem

The regional planning board is offering your team the chance to develop a new community in your area. You will need to look at the opportunities your region has to offer, and try to maximize them on a human scale. This will require you to do some research and to coordinate your planning among the sub-groups on your team. The sub-groups of your team will each need to address the components listed below. However, they will need to consult with the other sub-groups to coordinate their efforts. All solutions must consider the impacts to the inhabitants and their neighbors, the local ecology, and the regional environment. Be sure to utilize other classes in this project.

The Components

Sub-groups should be divided among the following components. Sub-group sizes will depend on the size of the whole group (class). You will need to make sure that your sub-group interfaces with the other sub-groups during the planning phase.

A. Regional Planning Interface Group – This group will be responsible for coordinating the whole effort, and helping resolve any conflicts that occur between sub-groups. It should also ensure that all solutions have minimum negative impacts and maximum positive impacts. All groups need to report to this group before any changes can be made to the model.

B. Transportation Group – This group will be responsible for all of the communities' transportation needs, movement in and out of the city, within the city, and any special requirements

for business and industry. It should be aware of possible growth and should consider environmentally friendly transportation modes and alternatives.

C. **Business/Industry Group** – This group will be responsible for encouraging business and industry compatible with the regional ecology, environment, and local resources. It will work closely to help decide where to locate business/industry to ensure the following: access to transportation, access to consumers, minimizing pollution, and other concerns. It should be concerned with recycling, developing green products, and housing business and industry facilities in green buildings.

D. **Public Works Group** – This group will be responsible for the type and location of the following: phone and electric, access to information services, sanitation (garbage and sewer), water, and regional needs such as snow removal, leaf removal, etc. Alternatives should be researched, and recycling should be stressed where possible.

E. **Construction Group** – This group is responsible for developing guidelines for human scale and environmental friendly buildings, both residential and business. Green buildings and renewable resources should be encouraged, along with sound conservation techniques, recycled materials, and energy efficient appliances.

F. **Parks and Leisure Group** – This group is responsible for the development and location of parks, recreation, exercise, and leisure venues. This may include local museums, parks, historical sites, and travel to regional attractions. Exercise trails and parks can be coordinated with transportation, serving residents and business/industry workers, as well as other city functions.

The Solution

The total group will plan and build a scaled model of its community. The size and complexity of the model will vary depending on the access to tools, machines, and supplies in the technology program. Each component should be scaled and labeled, and information should be described for each component, either on the model and/or in a separate presentation, which may be a report, brochure, radio or TV commercial, PowerPoint (or similar), Web site, etc. Photographs (digital or standard), video, or drawings should be part of the solution and included in the presentation.

The Presentation

The class should decide on a format for the presentation, with input from the instructor. Examples of some mediums are listed above, although the students are not limited to those, nor do they need to choose just one medium. Each sub-group should provide input into the presentation. Once the model and presentation are complete, the class should present the model to local groups of interest.

Reflection

Each student will be required to keep journal notes based on his or her work in the following: within their sub-group, within the total class, about the presentation, and how the presentation was received by people outside of the class. Notes may include reference notes, drawings, opinions, quotes, or other reflections on what they learned or what they may do differently the next time around.

Unit 4 – Lesson 3

Debating Current Technologies and Their Issues

Lesson Duration: Six (6) hours.

STL Standards

- Students will develop an understanding of the relationships among technologies and the connections between technology and other fields. (3)
- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop an understanding of the effects of technology on the environment. (5)
- Students will develop an understanding of the role of society in the development and use of technology. (6)
- Students will develop an understanding of and be able to select and use information and communication technologies. (17)

STL Benchmarks

- Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. (3H)
- Making decisions about technology involves weighing the trade-offs between the positive and negative effects. (4I)
- Ethical considerations are important in the development, selection, and use of technology. (4J)
- Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment. (5L)
- The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. (6I)
- Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. (17N)

Learning Objectives

Upon completion of this lesson, students will be able to:

1. Research current or upcoming technologies, gaining insight into the issues involved with their development from a variety of perspectives.
2. Examine technological issues from multiple facets, including technological, economic, political, cultural/ethical, environmental, or other societal implications.
3. Develop information relevant to the debate position assigned to inform, persuade, and educate the opponent, and develop counter arguments to potential views of the opponents.
4. Articulate a point of view during a debate format.
5. Reflect on points of view from others, and reformulate a position.
6. Communicate their mathematical thinking coherently and clearly to their peers, teachers, and others.
7. Recognize that progress in science and invention depends heavily on what else is happening in society, and history depends on scientific and technological developments.
8. Recognize that technological problems often create a demand for new scientific knowledge, and new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research.

9. Understand that risk analysis is used to minimize the likelihood of unwanted side effects of a new technology, although the public perception of risk may depend on psychological factors as well as scientific ones.
10. Realize that human inventiveness has brought new risks as well as improvements to human existence.
11. Recognize that written records and photographic and electronic devices enable human beings to share, compile, use and misuse great amounts of information and misinformation.
12. View science and technology thoughtfully, being neither categorically antagonistic nor uncritically positive.
13. Recognize when considering issues, that when people try to prove a point, they may select only the data that support that point and ignore any that would contradict it.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.
4-3A.
4-3B.
4-3C.
4-3D.
4-3E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected of him/her.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Preparation

Category	Below Target	At Target	Above Target
Material	Little evidence of researching material.	Material appears to be well researched.	Evidence of a lot of research.
Outline	Material did not appear to be well organized.	Material well organized.	Material very well organized and cross referenced throughout.
Complexity	Barely touched on one side of the issue.	Well versed in both sides of the issue.	Extremely prepared with both sides of the issue and counter info.

Assessment Instrument – Debate

Category	Below Target	At Target	Above Target
Opening	Opening remarks confusing or inappropriate to the issue.	Presented a good introduction that was convincing.	Extremely convincing argument, group is very confident.
Clarity	Arguments and counter arguments confusing.	Makes good points and is able to counter the other side reasonable.	Very clear in explaining points and doing rebuttals.
Demeanor	Not sure of their side, tends to get argumentive.	Remains calm and confident.	Is poised throughout and confident with all statements and aguments.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Preparation	As per above			
Debate	As per above			

Resource Materials

- Print-Based Sources
  - *Social Issues in Technology* (1986) Paul Alcorn
  - *Biotechnology Unzipped* (1997) Eric Grace
  - *Taking Sides: Views on Controversial Issues in Science, Technology and Society* (2005) 6th ed. Thomas Easton
- Audiovisual Materials
  - *Wind Over Water: The Debate Over Wind Power* (videoproject.com)
  - *Oil on Ice: Artic National Wildlife Refuge* (bullfrogfilms.com)
- Internet Sites
  - www.debating.net/flynn/ – world debating website with tutorial

Purpose of Lesson

To research and debate current and upcoming technologies from a variety of perspectives.

Required Knowledge and/or Skills

Students should have the ability to research current or upcoming technologies, evaluate the information from a variety of sources and viewpoints, and be able to prepare for and participate in a technological debate.

Engagement

1. The teacher may begin by describing a controversial new technology, and have the students discuss how they view the new technology: Do they embrace it or do they think it should not be used or developed? An example, such as human cloning, may serve to get multiple viewpoints from the class.
2. Review with students previous lessons on the issues that affect the decision to use or develop a technology. They should recall that the issue may reflect technological, economic, political, cultural/ethical, environmental, or other societal implications.
3. Students should develop a list of current or upcoming technologies that may create some issues and debate as they are introduced or developed.

Exploration

1. The teacher may discuss why we have a variety of viewpoints. The students should discuss how opinions are not the same as facts, and how facts affect opinions.
2. Working in small teams, students will research a particular controversial technology, gathering information from a variety of sources and viewpoints.
3. The student teams will organize information to support their points of view as well as information that may be helpful in persuading others with opposite viewpoints.

Explanation

1. The teacher will suggest controversial technologies that may be used in class debates. The teacher may provide historical technological debates as an introduction, which may include: surgery practices, new medicines, sending people into outer space, nuclear power, or others.
2. The teacher should lead a discussion on how biases or special interests may affect how people select and use information or scientific data to support their point of view. Students can discuss how other social institutions affect decisions on which technologies are developed and used.
3. Students should also discuss how it is important to know the source of the information they are gathering, and with what alliances the people from those sources may be involved.
4. The teacher may review sound debating techniques, and with the class develop a set of guidelines for the actual debates to keep them lively, but civil.

Extension

1. Students will select a topic and research information with their team members (no more than three members should make up a team).
2. Student teams will gather and organize information on their topics from multiple sources and points of view. All sources should be documented.
3. Student teams will prepare and debate teams from opposite points of view on technological devices or processes.
4. Students will reflect and discuss how their points of view may have changed following the debates.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, preparation, and debate.

Additional Extension Activities

1. Students may prepare and debate students from other classes, or neighboring schools. If possible, they may even debate teams from farther away using distance classroom technology.
2. Student debates may be taped for use on local television stations.
3. Students may take a field trip to witness a political debate, or discuss one in class following a nationally televised debate.

Laboratory-Classroom Preparation

Students should have access to information gathering and research, room for small group discussion, debate forum set, and possibly videotaping equipment to tape the debates.

Tools/Materials/Equipment

Research materials and Web access
Computers/software/printers
Poster/sign maker
Video taping equipment/lights

Laboratory-Classroom Safety and Conduct

Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.

Assignment – Lesson 4-3
Debating Current Technologies and Their Issues

Selecting a Technology

Select a current or emerging technology that has related technological and/or social issues. Research the issues surrounding the adoption of the technology. These issues may include technological, economic, political, environmental, or other social implications. Based on the issues, your team will represent a case for or against the adoption of the technology. However, you will need to review all sides of the issue in order to properly debate the opposing team. Be sure to record the publishing information for each reference you use. A few technology examples are provided here, and are categorized:

Information: downloading music, television/movie ratings, cell phone use in school
Manufacturing: outsourcing jobs, import quotas, export quotas, planned obsolescence
Transportation: building a new highway, alternative fuels, using nuclear power to make hydrogen, supersonic transport
Construction: impact studies, use of wood products, new vs. remodeled housing
Biotechnology: genetically altered foods, radiated foods, artificial limbs or organs, cloning, stem cell research
Technology and Design: plastics vs. natural materials, costs of ergonomic products, function vs. form

Researching the Issues

Your team's research may include technological, economic, political, environmental, or other social implications. What are the apparent advantages and/or disadvantages of adopting the technology? Are there parts of the technology that are safer than other parts? Do some advantages outweigh other disadvantages? (Note: This is often an opinion based on the facts available—you need to do your homework.) Be sure to document your sources for use during the debate, including page numbers. You can use the chart on the worksheet as you research and later use it to prepare for the debate. The worksheet chart can be reproduced as needed.

Preparing for Debate

Following the collection of your data, your team should organize its information to support your side of the argument. Your team should outline the benefits for an opening statement. You should also consider the opposite team's concerns and look for support to refute or lessen the other team's concerns. During the debate, it is beneficial to remain calm and stick to the information you have researched. It is important to remember that both sides of technological issues will have support, and there may not be a "correct" conclusion.

Reflection

Following the debate, your team will be asked to reflect on the experience. What did the team do well when preparing for the debate? What could have been improved? What did the team do well when presenting the debate? What could have been improved? Based on the other team's research and presentation, in what way(s) have the team members changed their views on the issues?

Assignment Worksheet – Lesson 4-3

Team Names: **Technology:**

Date: **Stance (for or against):**

Research (copy as needed)

Type of Issue	Advantages (benefits)	Disadvantages (risks)
Technological		
Social Impacts		
Legal Considerations		
Economic Impacts		
Environmental Impacts		
Cultural & National Sovereignty		
Community Impacts		
Other Issues _____		

Bibliography (list all sources used, including page numbers, continue on back if needed)

Outline and Notes for Debate (include opening statement and notes for rebuttal)

Reflection Place in Journal (use additional pages as necessary)

1. What did the team do well in preparation and debate?

2. What improvements would have helped the team in preparation and debate?

3. Based on the debate, how has the team (or individual members) changed in its view of the issue?

Unit 4 – Lesson 4

Protecting Technology

Lesson Duration: Six (6) hours.

STL Standards

- Students will develop an understanding of the characteristics and scope of technology. (1)
- Students will develop an understanding of the core concepts of technology. (2)
- Students will develop an understanding of the relationships among technologies and the connections between technology and other fields. (3)
- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop an understanding of the effects of technology on the environment. (5)
- Students will develop the abilities to apply the design process. (11)
- Students will develop an understanding of and be able to select and use information and communication technologies. (17)

STL Benchmarks

- The nature and development of technological knowledge and processes are functions of the setting. (1J)
- Requirements involve the identification of criteria and constraints of a product or system and the determination of how they affect the final design and development. (2AA)
- Technological ideas are sometimes protected through a process of patenting. (3I)
- Ethical considerations are important in the development, selection, and use of technology. (4J)
- The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. (5J)
- Identify criteria and constraints and determine how these will affect the design process. (11N)
- Develop and produce a product or system using the design process. (11Q)
- Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. (17N)

Learning Objectives:

Upon completion of this lesson, students will be able to:

1. Examine reasons for and abuses of the protection of technology and intellectual property.
2. Describe methods of protecting technology and intellectual property, including trade secrets, trademarks, copyrights, logos, and patents.
3. Research and employ protection methods to a technological device or process.
4. Research methods of patenting an innovation, invention, or process.
5. Develop packaging designs that incorporate protective information.
6. Make decisions about units and scales that are appropriate for problem situations involving measurement.
7. Solve problems using scale factors, including ratio and proportion.

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.
4-4A.
4-4B.
4-4C.
4-4D.
4-4E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected of him/her.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported efforts of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Product Designs

Category	Below Target	At Target	Above Target
Thoroughness	Many design areas not explored in the research, or not documented.	Most design areas explored and well documented and developed.	Many design areas explored, beyond base assignment, and well documented and developed
Components	Components missing, little or no documentation.	Most components included and easy to find.	All components well fulfilled and additional ones met
Creativity	Designs not very creative and somewhat boring.	Designs creative, showing a good deal of planning.	Designs extremely creative, showing a good deal of thought went into development.
Appropriateness	Designs not well related to product or intended audience.	Designs have good connection to product and intended audience.	Designs very well connected to product and thoughtfully consider the intended audience.

Assessment Instrument – Protection Research

Category	Below Target	At Target	Above Target
Variety of Sources	Used very few or insufficiently varied sources.	Used multiple sources with multiple perspectives.	Used many sources with a variety of viewpoints.
Documentation	Little or inadequate documentation.	All sources documented and done so properly.	Documentation well developed and referenced.
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.

Assessment Instrument – Debate

Category	Below Target	At Target	Above Target
Opening	Opening remarks confusing or inappropriate to the issue.	Presented a good introduction that was convincing.	Extremely convincing argument, group is very confident.
Clarity	Arguments and counter-arguments confusing.	Makes good points and is able to counter the other side reasonably.	Very clear in explaining points and doing rebuttals.
Demeanor	Not sure of his/her side, tends to get argumentive.	Remains calm and confident.	Is poised throughout and is confident with all statements and aguments.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Preparation	As per above			
Debate	As per above			

Resource Materials

- Print-Based Sources
  - *Engineering by Design* (1999) Gerard Voland
  - *Product Design & Development* (2003) Karl Ulrich & Steve Eppinger
  - *Inventing, Inventors and Inventions* (1989) Jerry Flack
- Audiovisual Materials
  - *Accidental Inventions* (libraryvideo.com)
  - Discovery Channel has many interesting titles: http://dsc.discovery.com
  - *Inventors of the World* video series (libraryvideo.com)
- Internet Sites
  - www.uspto.gov/ – United States Patent and Trademark Office homepage
  - www-wsl.state.wy.us/sis/ptdl/links.html – Patent and trademark links
  - www.inventorhelp.com/ – United Inventors Association

Purpose of Lesson

To identify, research, and develop methods of protecting technology.

Required Knowledge and/or Skills

Students should have the ability to research the protection of technology and other intellectual property, and be able to design and create examples for technological products.

Lesson 4-4:

Engagement

1. The teacher may begin with a discussion of the ethics of downloading music from the Internet. Who benefits, and who pays? Students should discuss what legal, ethical, and other social issues are involved with this type of technology transfer.
2. Students should list other examples where one group may want to develop and/or use technology without giving the creator credit.
3. The teacher should indicate that, in order to keep creative ideas coming, laws have been established to protect the creators and inventors of new ideas. Students should discuss what incentive there would be to create new ideas if there were no safeguards in place to enable people to be rewarded for their creativity?

Exploration

1. Working in small groups, students will use a technological product or process and investigate options to protect that technology.
2. The student groups will research product designs to help protect a technology.
3. Student groups will research options that will help legally protect their technology.
4. Students will develop product packages that incorporate protection notices.

Explanation

1. Teachers should explain that laws have been put in place to protect the transfer of technology (and other "property") that may occur without the consent of the technology's creators. An example they may be aware of is the copying of music files from the Internet. Property is classified in three forms: real (stationary property such as houses, land, etc.), personal (clothing, furniture, books, etc.), and intellectual (inventions, works of art, music, product names, etc.). Real property is protected by deeds; sales receipts protect personal property. It is intellectual property that includes forms of technology, including inventions and innovations, product names and logos, processes (such as steel manufacturing), and package designs.
2. Students should discuss legal protections, which can include trade secrets, trademarks, copyrights, and patents. Trade secrets, such as the recipe for Coca-Cola™, have no time limits; companies can keep the secret as long as no one discovers (through research) how it is made. Trademarks include product names, logos, and even a product's package. Trademarks can be renewed every five years, but will expire if the company cannot show that it made an effort to keep the public from using the term generically. Examples of brand names that have become generic include aspirin, nylon, formica, linoleum, thermos, and cellophane (although aspirin is still a brand name in Canada).
3. Students should be aware that copyrights protect expressions of intellect, but do not cover the specific idea or concept. For example, a student's algebra book protects the author's form of presenting algebra, but does not cover the concept of algebra itself. Patents also protect intellectual property. They include three types: utility (functional products, processes, or concepts), plant (specific to plant materials), and design (shape or form of an object—for example, the design of the Statue of Liberty is patented). Utility patents are currently good for 20 years in the U.S. These provide a "reward" for the creator, by allowing him or her to make a profit from his or her idea before others are given the opportunity.
4. Students should discuss how these protections allow creative ideas to continue to flourish and provide incentives for people to continuously create and innovate technology.

Extension

1. Students will work individually or in groups to develop ideas to help promote, market, and protect a selected technology.
2. Students will develop ideas and models of trademarks, logos, package designs, and other protection designs for a technology product.
3. Students will research information, processes, and costs of legally protecting a technological product.
4. Students will present their findings and designs to the class.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, product designs, protection research, and presentation.

Additional Extension Activities

1. Students may apply these processes to other technology classes, such as the Engineering Design class.
2. Engineers or inventors could be brought into class as speakers.
3. Student presentations should be prominently displayed in the school for a period of time.
4. Student research and presentations could be collated for distribution.

Laboratory-Classroom Preparation

Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations. Bench space and graphic tools for model development should also be available.

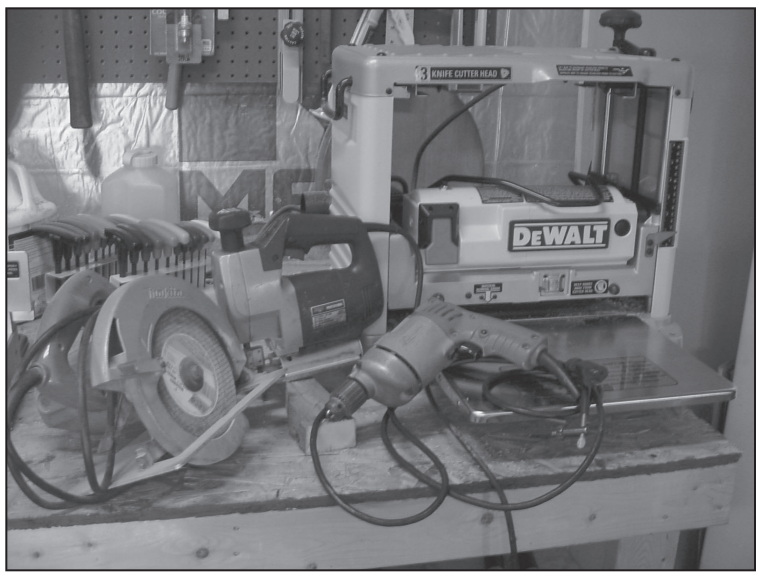
Tools/Materials/Equipment

Research materials and Web access
Computers/software
Tools and materials for graphic representations
Measuring and other simple tools for developing packages
Printers
Poster/sign maker

Laboratory-Classroom Safety and Conduct

Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.



Logos and product names (and colors) can be seen in many products, such as tools found in the technology lab or at home.

Assignment – Lesson 4-4
Protecting Technology

Select a Technology
Select a new, upcoming, or undeveloped technology. You may use a fictitious technology for this activity, or you may use the technology you developed in Unit 4, Lesson 1. Working individually or in small groups, you will develop the product further, including any necessary trade secrets, trademarks, logos, package designs, copyrights, or other intellectual property. All of this property can be designed to help promote, market, and protect the technology. Following your product development, you will investigate how to protect each of your intellectual designs.

Develop Your Product
Once you have selected a technology, brainstorm, develop, and design any trade secrets, trademarks, logos, package designs, copyrights, or other intellectual property. Not all of these items will be applicable to every technology—select and develop those that apply. Be creative in your designs, and be careful not to infringe upon existing designs. You will need to brainstorm and document as many ideas for each category as possible. The more ideas you or your group generate, the better chance you will have of developing a good design. Place your ideas in a journal or related resource. You may use the table on your worksheet to help develop ideas.

Research Technology Protection
For each of the designs you have developed, select one that you feel best represents your technology, and design it as a mock-up or prototype. Use proper design processes. Place your developed work in your journal (documentation is very important, especially in protecting your ideas). Make sure your design is unique, and does not infringe on other previous designs.

For each design, research the process of protecting your intellectual property. For example, if you have designed a trademark, research what is necessary to get the design protected, including what needs to be submitted, costs, where to send information, timeframes, how long you are protected, etc. If you have created an invention or innovation (possibly from Unit 4, Lesson 1), what would need to be submitted? You should start by looking at the United States Patent and Trademark Office (www.uspto.gov/). You can use the table on the worksheet (next page) to document your research.

Presentation
Present your technology to the class. Also present any designs you have developed, including trademarks, logos, special packages, etc. Describe any unique ideas you or your group has developed and any special requirements necessary to protect your intellectual property. If your ideas are top notch, be sure to document, date, and safeguard any of your ideas until they can actually be protected!

Assignment Worksheet – Lesson 4-4

Student Name(s): **Technology:**

Date:

Product Development

Develop multiple ideas for any categories that apply to your technology on the table below. Copy as needed. Transfer your ideas, sketches and drawings to your journal or similar resource. Be sure to date all your entries. The more ideas you generate the better chance you have to develop a good design.

Category	Ideas
Trade Secret	
Trademark	
Copyright	
Logo	
Process	
Package Design	
Invention	
Innovation	

Protection Research

For each category you have developed for your technology, research the necessary information for protecting your intellectual property. Use the table below to answer all the necessary questions from the handout. Be sure to document your sources. Copy as needed. Transfer the important information to your journal.

Category	Ideas
Trade Secret	
Trademark	
Copyright	
Logo	
Process	
Package Design	
Invention	
Innovation	

Unit 5
Predicting Technological Issues

Engineering By Design
A National Model for Standards-Based Programs

Unit 5: Predicting Technological Issues

STL Standards

- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop an understanding of the role of society in the development and use of technology. (6)
- Students will develop an understanding of the attributes of design. (8)
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation and problem solving. (10)
- Students will develop the abilities to assess the impact of products and systems. (13)

STL Benchmarks

- Making decisions about technology involves weighing the trade-offs between the positive and negative effects. (4I)
- The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. (6I)
- Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. (8K)
- Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. (10I)
- Technological problems must be researched before they can be solved. (10J)
- Collect information and evaluate its quality. (13J)
- Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment. (13K)
- Use assessment techniques, such as trend analysis and experimentation to make decisions about future development of technology. (13L)
- Design forecasting techniques to evaluate the results of altering natural systems. (13M)

Mathematics Standards

4 F Represent, analyze, and generalize a variety of patterns with tables, graphs, words, and, when possible, symbolic rules.

6F Draw reasonable conclusions about a situation being modeled.

14 H Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population.

14J Understand the differences among various kinds of studies and which types of inferences can legitimately be drawn from each.

21C Recognize and apply mathematics in contexts outside of mathematics.

22C Use representations to model and interpret physical, social, and mathematical phenomena.

Science Standards

8J In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.

8K The value of any given technology may be different for different groups of people and at different points in time.

8M Risk analysis is used to minimize the likelihood of unwanted side effects of a new technology. The public perception of risk may depend, however, on psychological factors as well as scientific ones.

9Q Social and economic forces strongly influence which technologies will be developed and used. Which will prevail is affected by many factors, such as personal values, consumer acceptance, patent laws, the availability of risk capital, the federal budget, local and national regulations, media attention, economic competition, and tax incentives.

9S In deciding on proposals to introduce new technologies or to curtail existing ones, some key questions arise concerning alternatives, risks, costs, and benefits.

41J Computer modeling explores the logical consequences of a set of instructions and a set of data. The instructions and data input of a computer model try to represent the real world so the computer can show what would actually happen.

65Q Use tables, charts, and graphs in making arguments and claims in oral and written presentations.

66N Be aware, when considering claims, that when people try to prove a point, they may select only the data that support it and ignore any that would contradict it.

Big Idea
A variety of tools and processes are available to predict outcomes of designs or problem solutions in advance, thus limiting negative technological issues.

Unit 5 Objectives

At the completion of this unit, students will be able to:

- Examine case studies of technological issues and their resolution.
- Examine modeling, simulations, and other techniques to minimize technological issues.
- Research an emerging or future technological development and assess its possible effects on individuals, groups, or society.
- Examine an emerging or future technological solution using forecasting techniques.

Assessment

Assessment for each lesson includes a quiz, and rubrics will be used for group work and/or parts of the research, analysis, and presentation.

Teacher Preparation

Teacher preparation for this unit should include:

- Gather references, or make available examples of historical changes and technological innovations and inventions. As students discover good references, Web sites, films/documentaries, local historical sites, etc., develop a database.
- Research historical events to examine their technological and social interactions. Develop a list of potential topics for the students.
- Discuss with other teachers what students are studying in their classes, including history, economics, social studies, science, mathematics, and other technology classes, and how those concepts are related to technological issues.
- Gather examples of technological and/or social issues that are current from news articles or media presentations.
- Review teaching methodologies used in lessons one through four.
- Make copies of the assignments (one page, double-sided if need be) and the worksheets (one page, double-sided if need be) for each student or group.

Unit *5* – Lesson 1

Weighing and Prioritizing Design Trade-Offs

Lesson Duration: Four (4) hours.

STL Standards

- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop an understanding of the role of society in the development and use of technology. (6)
- Students will develop an understanding of the attributes of design. (8)
- Students will develop the abilities to assess the impact of products and systems. (13)

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STL Benchmarks

- Making decisions about technology involves weighing the trade-offs between the positive and negative effects. (4I)
- The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. (6I)
- Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. (8K)
- Collect information and evaluate its quality. (13J)
- Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment. (13K)
- Use assessment techniques, such as trend analysis and experimentation to make decisions about future development of technology. (13L)

Learning Objectives

Upon completion of this lesson, students will be able to:

1. Select a technological device and compare various products from different vendors.
2. Develop a series of trade-off parameters (design goals) for evaluating multiple products.
3. Rank-order design parameters based on perceived importance.
4. Evaluate various products based on design trade-offs and their weighted factors.
5. Analyze the design optimization process.
6. Represent, analyze, and generalize a variety of patterns with tables, graphs, words and, when possible, symbolic rules.
7. Draw reasonable conclusions about a situation being modeled.
8. Recognize and apply mathematics in contexts outside of mathematics.
9. Use representations to model and interpret physical, social, and mathematical phenomena.
10. Recognize that in designing a device or product, thought must be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.
11. Understand that the value of any technology may be different for different groups of people and at different points in time.
12. Recognize that, in deciding on proposals to introduce new technologies or curtail existing ones, some key questions arise concerning alternatives, risks, costs, and benefits.
13. Use tables, charts, and graphs in making arguments and claims in oral and written presentations.

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.

5-1A.
5-1B.
5-1C.
5-1D.
5-1E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected of him/her.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Design Matrix

Category	Below Target	At Target	Above Target
Parameters	Very few or inappropriate parameters selected.	Many appropriate parameters identified.	All parameters well thought out and very appropriate to the design.
Organization	Matrix not well organized —hard to follow.	Matrix well organized and easy to follow.	Matrix exceptionally well organized and flows very well.
Using calculations and/or formulas	Incorrect formulas used or correct formulas used incorrectly.	Formulas selected and used appropriately.	All correct formulas selected and used properly and checked using alternative methods.
Analysis	Parameters not weighted or inappropriately weighted.	Parameters well designed and weighted according to good planning and research.	Parameter weightings and design very well thought out and researched.

Assessment Instrument – Analysis/Presentation

Category	Below Target	At Target	Above Target
Thoroughness	Many areas not explored in the research, or not documented or analyzed properly.	Most areas explored and well documented and analyzed.	Many areas explored, beyond base assignment, and well documented and analyzed.
Components	Presentation not well organized—hard to follow	Presentation well organized and easy to follow.	Presentation exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation was creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Design Matrix	As per above			
Analysis/Presentation	As per above			

Resource Materials

- Print-Based Sources
  - *Cradle to Cradle: Remaking the Way We Make Things* (2002) W. McDonough & M. Braungart
  - *Engineering by Design* (1999) Gerard Voland
  - *Product Design & Development* (2003) Karl Ulrich & Steven Eppinger
- Audiovisual Materials
  - *Industrial Systems of Tomorrow: Finding Sustainability Through Natural Cycles* (videoproject.com)
  - *Masters of Technology* (shop.wgbh.org)
- Internet Sites
  - www.consumerreports.org/index.html – for ideas on evaluation criteria see how they do it at Consumer reports Web site

Purpose of Lesson

To develop and weight-design criteria to optimize a technology.

Required Knowledge and/or Skills

Students' should be able to research various products, develop and use design trade-off matrices, and properly make the necessary calculations required for analysis.

Lesson 5-1:

Engagement

1. The teacher may begin by asking students to think of all the products of technology around them. This may include personal items such as clothes, watches, bicycles, books, and many others. It includes household items such as toasters, microwaves, clocks, televisions, etc. It includes items in school and in the workplace, such as tools, machines, computers, furniture, etc. It also includes large infrastructures, such as power plants, highways, railroads, airports etc.
2. Students should discuss all of these examples. Is there such thing as a "perfect" design? They should see that the design process allows us to develop what we consider to be the best solution to the problem at hand. And, during the process, designers encounter times when they need to make some important decisions. They may have several options available for a solution, but need to make some compromises, or trade-offs.
3. Students should note that trade-offs cause us to give up something in order to satisfy another dimension of the design. They can discuss some trade-offs they need to make every day.
4. The teacher must stress that the students carefully define the problem. For example, problems occur in our selection and use of energy. Each energy source has trade-offs in its ease of use, availability, concentration, safety, environmental risks, health issues, externalities (hidden costs such as black lung from coal mining), and other parameters. However, if we examine our energy consumption (such as electricity), we may want to define the problem in terms of the end use.

Exploration

1. Working in small groups, students will examine technological devices or processes to compare similar items and how the designers addressed various trade-off issues.
2. Student groups will develop a matrix of design trade-off parameters, and assign weights to each based on perceived matching of design goals and criteria.
3. Students may compare the design they completed in Unit 4, Lesson 1 to existing technologies, or select another technological device or process.

Explanation

1. The teacher should discuss with students the various trade-off issues apparent in specific devices that they have listed. What compromises or decisions did the designer(s) address? Give the students examples of how the following parameters are related: cost, performance, maintenance, aesthetics, availability of parts, number of parts, ease of use, versatility, types of materials, recyclability, amount of waste during production, and ease of production. They should be aware that many of these parameters compete against each other to satisfy the goals and criteria of a design problem.
2. The teacher should explain that trade-offs occur with all technological problems. They can be in the form of material selection, costs, product performance, or a variety of other design parameters. During this process, designers need to carefully weigh design wants versus needs, risks versus hazards, and form versus function. The weighing of those decisions is almost always subjective, but there are tools available to help with the trade-off process.
3. Students should realize that it is important to know that their evaluation of the design trade-offs will be subjective. The teacher can show them how they can develop a table of the parameters and weight each on the device's perceived need. For example, performance may be weighted higher than aesthetics for the design of a can opener, but may be the opposite for the design of a clothing item. Also, trade-offs also occur in social systems. Recall from Unit 4

that appropriate technology must address the use of humans versus machines in technology transfer situations. Additionally, risks and benefits affect different people at different times.

4. The teacher can provide an example of a weighted decision table, which is shown on the next page. It is a simplified scenario, the selection of an item of clothing. However, it will show the students how to construct a trade-off matrix. The designer(s) or person(s) making the decision establishes the weighting and rating factors. These are always subjective, but they should be based on the design statement and the goals and criteria of the problem. For example, another designer might rate the aesthetics higher than the cost in another decision matrix. The decision factor is the product of the weighting factor times rating factor. Product A has a rating factor for performance of 8, times the weighting factor of 100, which produces a decision factor of 800. The decision factors are then summed in the total column. The design with the highest total, Product B with 2350, is selected as the optimized solution, with the best trade-off decision. The teacher may want to develop a matrix with the students in class in order for them to see how the factors are chosen, and how the calculations are made.
5. The teacher should explain that engineers and technicians, who work with technology design problems, define the process of examining trade-off issues as optimization. Simply put, optimization means developing the best solution to a problem—one that is effective and economical. They use similar techniques to those discussed by the students above. However, it is not always an easy process, and they must address some of the social issues examined in Unit 1. The decisions are always subjective, and they can often involve cultural values. For example, the use of animals in product research can be perceived differently based on our cultural values. Additionally, cultural values can change over time. What we view as acceptable risks today may be different in the future, based on what happens between now and then.

Extension

1. Students, working in small groups, will select a technological device and examine several different brands of that device.
2. Student groups will develop and use a trade-off decision matrix.
3. Students will analyze the products based on the matrix, and present the results to the class.
4. Students will reflect on the process of weighting design trade-offs.

Table 4 Trade-Off Decision Matrix

	Goals				
	Performance	**Costs**	**Asthetics**	**Maintenance (ease of care)**	
	Weighting Factors				
	100	90	80	70	Total
Product A	8/800	6/540	5/400	6/420	2160
Product B	6/600	7/630	7/560	8/560	2350
Product C	5/500	8/720	6/480	5/650	2050
Product D	9/900	6/540	4/320	5/650	2110

Evaluation
Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, design matrix, and analysis/presentation.

Additional Extension Activities
1. Students may evaluate their designs from past activities in this course as opposed to using commercial products available for the same purpose.
2. A local designer or engineer may speak to the class about a recent design process.
3. Student work should be prominently displayed in the school for a period of time.
4. Student presentations should be collated graphically or with multimedia for documentation and/or distribution.

Laboratory-Classroom Preparation
Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations. Tools, devices toys, etc. (technological devices) should be accessible along with measuring and other simple tools required for the analysis of the devices.

Tools/Materials/Equipment
Research materials and Web access
Computers/software
Tools and other technological devices for examination
Measuring and other simple tools for analysis of devices
Printers
Poster/sign maker

Laboratory-Classroom Safety and Conduct
Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.

Assignment – Lesson 5-1
Weighting and Prioritizing Design Trade-Offs

Selecting a Technological Device

Select a technological device or process that has multiple designs from various sources or companies. You will be examining how each designer used trade-offs to determine their final product. If possible, you may compare the product you design in Unit 1, Asignment 3 and compare it to similar products. You may work individually or in small groups. A few technology examples are provided here, and are categorized:

Information: radio, television, digital camera, computer, cell phone, MP3 player
Manufacturing: CD rack, kitchen tool, clothing item, school product, toy
Transportation: bicycle, automobile, watercraft, motorcycle, quad, riding mower
Construction: hand tool, power tool, appliance, light fixture, roofing material, siding material
Biotechnology: food product, medicine, agricultural process, horticultural process
Technology and Design: camping fold-up chair, keyboard, refrigerator, package design, ergonomic tool, sports accessory

Design Trade-Off Parameters

Once you have selected a particular technological device, you will need to decide on the design trade-off parameters that you will use to evaluate multiple products. These may include cost, performance, maintenance, aesthetics, availability of parts, number of parts, ease of use, versatility, types of materials, recyclability, amount of waste during production, and ease of production. You or your group may also think of other design parameters, depending on the technology selected. Select as many as apply to your decision-making process. Next, you will need to rank-order each trade-off or design goal. Assign them a weighted factor number from 100 down, based on your perceived importance of each item. If you are working in small groups, these items should be discussed and agreed upon. You may want to rank them in multiples of 5 or 10 (100, 95, 90, etc.) for ease of calculations.

Decision Evaluation Matrix

Develop a trade-off decision matrix, using the example below and on your worksheet. The design goals will be listed across the top. Use all that you have selected in the last step (the example below has only four, your matrix may have more). The various similar products you have selected will be listed down the first column; in this example we are comparing four radios. In your example, you may have more or fewer products to compare. Next, evaluate each product for each design goal, and give it a rating from 10 (highest) down to one (lowest). You may need to compare all the products for each design goal to determine the ratings, based on comparisons. You may wish to develop your matrix using a spreadsheet program, which will allow you to easily calculate your totals and make quick changes if necessary.

	Design Goals				
	Goal 1	**Goal 2**	**Goal 3**	**Goal 4**	
	Weighting Factors				
	100	90	80	70	Total
Radio A	6/600				
Radio B					
Radio C					
Radio D					

Analysis

Rate each product for each design goal. Calculate the decision factor for each cell by multiplying the rating factor times the weighting factor. For example, radio A has a rating factor of six, which when multiplied by the weighting factor of 100, provides a decision factor of 600. Once all of the cells are completed, add all of the decision factors for each product and place in the totals column on the far right. Complete the analysis on the worksheet.

Designing an ergonomic product.

Assignment Worksheet – Lesson 5-1

Student Name(s): **Technological Device:**

Date:

Design Trade-Off Parameters

Develop a list of parameters in the space below that apply to your technological device or process. Rank-order them and assign each a weighting factor from 100 down.

Brainstorm list **Rank-order** **Weighting Factor**

Trade-Off Design Matrix

Develop a trade-off decision matrix. You can use the example below to collect and organize your information. When you develop your final matrix, you may wish to use a spreadsheet or similar program to help you organize, calculate, and easily change your information. Add or omit goals and/or products as needed.

	Design Goals						
	Goal 1	**Goal 2**	**Goal 3**	**Goal 4**	**Goal 5**	**Goal 6**	
	Weighting Factors						
	100	95	90	85	80	75	Total
Product A							
Product B							
Product C							
Product D							
Product E							

Analysis

For each product and each design goal, select a rating factor from 10 (highest) to 1 (lowest). Calculate the decision factor for each cell (see example in the assignment sheet). You may need to examine all products for each design goal at the same time in order to base your comparison and arrive at a rating factor. Calculate the decision factor and complete the matrix. Add the totals for each product in the right column.

Individually, or as a small group, answer the following questions. Type them up and hand them in with your completed, printed matrix.

1. Which product provided the optimal solution?

2. Did the product selected have problems that need to be considered during the trade-off exercise?

3. Was it difficult to assign rating factors? Why or why not?

4. How did you determine the weighting factors? Was that difficult?

5. Did you need to change your weighting or rating factors during the process? If so, why?

6. Reflect on how this process could be used for other decisions.

7. Provide suggestions to modify this process, and give reasons for the change(s).

Unit *5* – Lesson 2

Using Models, Simulations, and Games

Lesson Duration: Six (6) hours.

STL Standards

- Students will develop an understanding of the role or troubleshooting, research and development, invention and innovation, and experimentation and problem solving. (10)
- Students will develop the abilities to assess the impact of products and systems. (13)

STL Benchmarks

- Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. (10I)
- Technological problems must be researched before they can be solved. (10J)
- Collect information and evaluate its quality. (13J)
- Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment. (13K)

Learning Objectives

Upon completion of this lesson, students will be able to:

1. Define various types of models: analog, ionic, verbal, and mathematical.
2. Examine various models and analyze their effectiveness and authenticity.
3. Define and give examples of a variety of simulations.
4. Evaluate simulations and analyze their effectiveness and authenticity.
5. Classify types of games, their purpose, and provide examples of each classification.
6. Evaluate various games and analyze their effectiveness and authenticity.
7. Apply models, simulations, and games to technological and social issues.
8. Draw reasonable conclusions about a situation being modeled.
9. Use representations to model and interpret physical, social, and mathematical phenomena.
10. Recognize that risk analysis is used to minimize the likelihood of unwanted side effects of a new technology, although the public perception or risk may depend on psychological factors as well as scientific ones.
11. Recognize that computer modeling explores the logical consequences of a set of instructions and a set of data that try to represent the real world, so that the computer can show what would actually happen.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.
5-2A.
5-2B.
5-2C.
5-2D.
5-2E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected of him/her.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Observations

Category	Below Target	At Target	Above Target
Models	Selection, use, and analysis of model unclear and confusing.	Selection of model appropriate, and analysis clear and thorough.	Model selection and analysis well conceived and very thorough.
Simulations	Selection, use, and analysis of simulation unclear and confusing.	Selection of simulation appropriate, and analysis clear and thorough.	Simulation selection and analysis was well conceived and very thorough.
Games	Selection, use, and analysis of game unclear and confusing.	Selection of game appropriate, and analysis clear and thorough.	Game selection and analysis was well conceived and very thorough.
Applications	Modeling selections not applied appropriately to real-world situations.	Modeling selections applied appropriately to real-world situations.	Modeling selections very well applied and appropriately matched to real-world situations.

Assessment Instrument – Analysis/Presentation

Category	Below Target	At Target	Above Target
Thoroughness	Many areas not explored in the research, or not documented	Most areas explored and well documented.	Many areas explored beyond base assignment, and well documented.
Components	Presentation not well organized—hard to follow.	Presentation well organized and easy to follow.	Presentation exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Design Matrix	As per above			
Analysis/Presentation	As per above			

Resource Materials

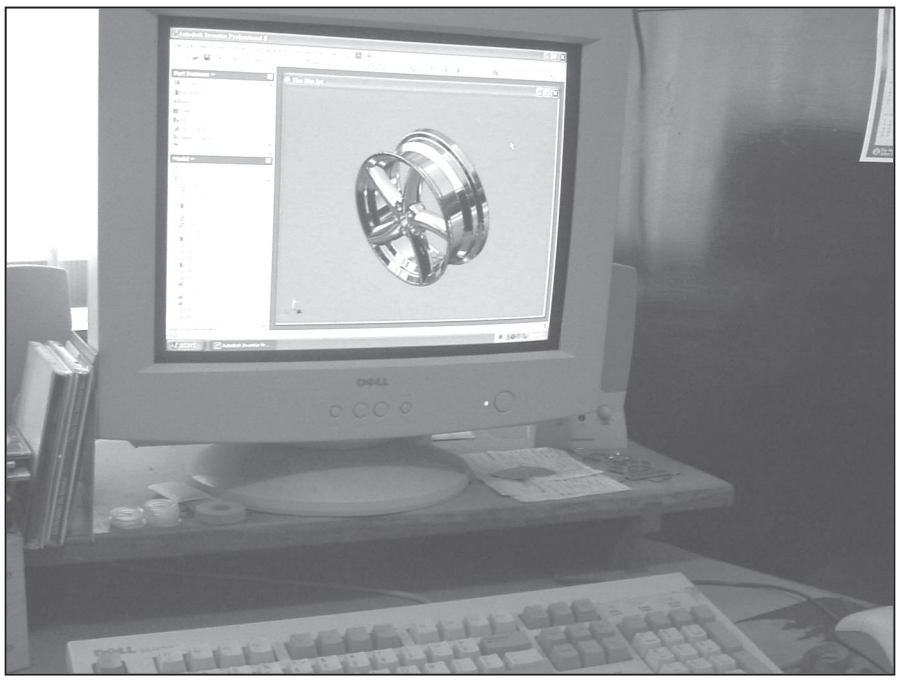
- Print-Based Sources
  Social Issues in Technology (1986) Paul Alcorn
- Audiovisual Materials
  Beyond 200: The Explorers (libraryvideo.com)
  Computer simulations and games
  Time Travel (shop.wgbh.org)
- Internet Sites
  htttp://simcity.ea.com/play/simcity_classic.php – Learn about and play the classic version of Sim City online

Purpose of Lesson

To examine and evaluate models, simulations, and games, and how they may be used to represent technological and social issues.

Required Knowledge and/or Skills:

Students should be able to select, use, and analyze the performance of predicting tools, including models, simulations, and games.



Computer software, found in many technology programs, can be used for modeling or simulations.

Lesson 5-2:

Engagement

1. The teacher may begin by asking why we use models, and then have the students form a definition. Models can be described as an imitation of a real physical device or process. Some are more realistic than others, and they may serve different purposes. For example, a model airplane may be appropriate to study the basics of flight but would be inappropriate for an engineer to use to study the effects of a new metal alloy on wings.
2. Students may also discuss simulations, and describe some they may have used. Some that are popular include Sim City and the other products of this company. Again, some simulations are more realistic than others, and have different purposes. As they become more realistic and complicated, many more hours goes into their development and programming.
3. Students should also discuss games. They can discuss some they have played that relate to real-world situations. They can discuss board games, computer games, or others. Discuss some of the similar features of all the games played.

Exploration

1. Working in small groups, students will examine and analyze technological models.
2. Working in small groups, students will examine and analyze technological simulations.
3. Working in small groups, students will examine and analyze technological games.

Explanation

1. The teacher should describe and discuss the various types of models: analog, iconic, verbal, and mathematical. Analog models behave similarly to the device they are modeling. A radio-controlled model airplane would be an example, using the same types of flight control surfaces as a real plane. They can also be used to predict the effects of erosion on soils or help study the effects of an earthquake on a building. Iconic models look like the device they are modeling, but do not behave they same way. Architectural models would be an example, as would many toys such as trucks or animals. They can be used to study non-performance phenomena, such as aesthetics, color, shape, texture or special relationships (such as the second lesson in Unit 4). Verbal models are descriptions of a device or system. They have limitations because they are open to various interpretations. Directions for the use or assembly of a device are examples of verbal models. Mathematical models use symbolic representations to describe a concept or system. They are used to predict how things may change by changing one of the variables. The development of an electronic device may use a mathematical model to look at how it will perform, power usage, loading factors, and others.
2. Simulations are a special form of models. They can combine analog and mathematical model principles. The use of computers has greatly increased the use and complexity of simulations. Simulations differ in their purpose. Complex simulations utilize secondary and tertiary effects, using multiple feedback loops of cause and effect.
3. Games can be classified as games of chance (such as poker), games of skill (sports or chess), or a combination ("Risk," war games, etc.) Specialized games that recreate real-world conditions are often classified as simulations.
4. The teacher will help the student groups select and analyze models, games and simulations.

Extension

1. Student groups will apply models, simulations, and games to technological and social issues.
2. Student groups will present their findings to the class.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, observations, and analysis/presentation.

Additional Extension Activities

1. Students may create, develop, and manufacture their own game based on rules they have designed and applications to their local setting.
2. Students may use a field trip to visit a regional interactive museum, using and analyzing the simulations available.
3. Students may use simulations to revisit assignments from earlier in the course to make improvements, such as Unit 4, Lesson 2.

Laboratory-Classroom Preparation

Students should have access to models, simulations, programs, and games for evaluation and analysis.

Tools/Materials/Equipment

Research materials and Web access
Computers/software
Models, simulations, and games available for evaluation.
Printers
Poster/sign maker

Laboratory-Classroom Safety and Conduct

Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.

Assignment – Lesson 5-2
Using Models, Simulations, and Games

Model Selection
Working in small groups, select a model to analyze. You may use one of the models available in the lab, or select a model that represents a technological device or process. Briefly describe the model below:

Model Analysis
Analyze the model based on the following questions (use this information in your presentation):

What type of model did you investigate?

How close to the real-world technology was the model you selected?

What attributes of the real-world technology were represented, and how well did they do so?

How could the model be improved, and what would be involved in those improvements?

Model Application:
Use the model (if possible) in a real-world situation. Describe how it performed and what improvements could be made to make it more effective:

Simulation Selection:
Working in small groups, select a simulation to analyze. You may use one of the simulations available in the lab, or select a simulation that represents a technological device or process (with instructor approval). Briefly describe the simulation below:

Simulation Analysis
Analyze the simulation based on the following questions (use this information in your presentation):

What was the purpose of the simulation you investigated?

How close to the real-world technology was the simulation?

What attributes of the real-world technology were represented, and how well did they do so?

How could the simulation be improved, and what would be involved in those improvements?

Simulation Application

Use the simulation in a real-world situation. Describe how it performed and what improvements could be made to make it more effective:

Game Selection

Working in small groups, select a game to analyze. You may use one of the games available in the lab, or select a model that represents a technological device or process or social situation. Briefly describe the game below:

Game Analysis

Analyze the simulation based on the following questions (use this information in your presentation):

What was the purpose of the game you investigated?

What types of rules and constraints were imbedded in the game?

What attributes of the real-world technology or social situations were represented, and how well did they do so?

How could the game be improved, and what would be involved in those improvements?

Game Application

Use the simulation in a real-world situation. Describe how it performed and what improvements could be made to make it more effective:

Presentation

Develop a clear, creative presentation to present your model, simulation, and game insights to the class.

Unit 5 – Lesson 3

Applying Technology Assessment Tools

Lesson Duration: Four (4) hours.

STL Standards

- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop an understanding of the role of society in the development and use of technology. (6)
- Students will develop an understanding of the attributes of design. (8)
- Students will develop an understanding of the role or troubleshooting, research and development, invention and innovation, and experimentation and problem solving. (10)
- Students will develop the abilities to assess the impact of products and systems. (13)

STL Benchmarks

- Making decisions about technology involves weighing the trade-offs between the positive and negative effects. (4I)
- The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. (6I)
- Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. (8K)
- Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. (10I)
- Technological problems must be researched before they can be solved. (10J)
- Collect information and evaluate its quality. (13J)
- Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment. (13K)
- Use assessment techniques, such as trend analysis and experimentation, to make decisions about future development of technology. (13L)

Learning Objectives

Upon completion of this lesson, students will be able to:

1. Define technology assessment and provide multiple examples.
2. Examine the role of government and other social institutions for technology assessment.
3. Describe multiple purposes of technology assessment.
4. Examine various technology assessment techniques and provide examples of their use.
5. Apply technology assessment techniques to technological problems.
6. Describe limitations to technology assessment.
7. Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population.
8. Understand the differences among various kinds of studies and which types of inferences can be legitimately drawn from each.
9. Use representations to model and interpret physical, social, and mathematical phenomena.
10. Recognize that risk analysis is used to minimize the likelihood of unwanted side effects of a new technology, although the public perception or risk may depend on psychological factors as well as scientific ones.

11. Understand that social and economic forces strongly influence which technologies will be developed and used, and will be affected by many factors, such as personal values, consumer acceptance, patent laws, the availability of risk capital, the federal budget, local and national regulations, media attention, economic competition, and tax incentives.
12. Recognize that in deciding on proposals to introduce new technologies or curtail existing ones, some key questions arise concerning alternatives, risks, costs, and benefits.
13. Be aware that when people try to prove a point, they may select only data that support it and ignore any that would contradict it.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.
5-3A.
5-3B.
5-3C.
5-3D.
5-3E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected of him/her.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Research

Category	Below Target	At Target	Above Target
Variety of Sources	Used very few or insufficiently varied sources and limited alternatives.	Used multiple sources and alternatives, with multiple perspectives.	Used many sources with a variety of viewpoints, many alternatives suggested.
Documentation	Little or inadequate documentation.	All sources documented and done so properly.	Documentation was well developed and referenced.
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.

Assessment Instrument – Presentation

Category	Below Target	At Target	Above Target
Organization	Presentation not well organized—hard to follow.	Presentation well organized and easy to follow.	Presentation exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.
Feedback	Audience did not participate in the presentation.	Audience attentive to the presentation participated when asked.	Audience was extremely interested and asked many questions.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Research	As per above			
Presentation	As per above			

Resource Materials

- Print-Based Sources
  - *Contemporary Technology* (1989) Linda Rae Market
  - *Technology, Change and Society* (1978) Edward Pytlik (et.al.)
- Audiovisual Materials
  - *Masters of Technology* (shop.wgbh.org)
  - *The Day After Tomorrow* (2004)
  - *The Next Industrial Revolution* (bullfrogfilms.com)
- Internet Sites
  - www.wws.princeton.edu/~ota/ns20/pubs_f.html – publications from the Office of Technology Assessment on file even though it was removed in 1995
  - http://www.icta.org/ – International Center for Technology Assessment
  - www4.nationalacademies.org/nas/nashome.nsf – National Academy of Science

Purpose of Lesson

To evaluate the process of technology assessment and apply assessment tools to technological problems and issues.

Required Knowledge and/or Skills

Students should be able to research technological issues and evaluate, organize, and present potential impacts and alternatives.

Lesson 5-3:

Engagement

1. The teacher may begin by discussing the 2004 movie *The Day After Tomorrow*. It was a heavily computer-generated tale of a global disaster due to global warming from greenhouse gases, a by-product of converting fossil fuels into energy and power. The movie quickly became political, as it was an election year, but the producers were quick to note it was partly science fiction and that we are not sure what the consequences of excess greenhouse gases may do to the environment. However, the film did the serve the purpose of making people aware of an important fact—all technologies, no matter how carefully planned, have impacts.
2. Students should discuss how we can predict the future. What predictions in the past have come true, and which ones are we still waiting for?
3. Students should discuss how fast technological advances have been produced. They should discuss if they are coming too fast, or whether we can cope with the changes. How can we know if the positive impacts of a technology will outweigh the negative impacts? Technology assessment is one method of evaluating future technological impacts. Technology assessment implies the use of foresight, logic, statistical analysis, and awareness of current trends.

Exploration

1. Students, working in small groups, will select a technological issue and examine potential impacts.
2. Student groups will organize potential impacts into a table matrix.
3. Student groups will analyze and present their findings to the class.

Explanation

1. The teacher should make the students aware that all technologies have impacts, both positive and negative. These impacts may affect other humans or social institutions, may affect ecological systems and other organisms, or may affect the environment. Some of the impacts of a new technology are intentional, such as the increased mobility and speed afforded us through the development of the automobile. Some impacts are unintended; we simply did not predict them. Pollution from automobiles was not considered during its introduction. Hence, we can develop a matrix of impacts from each technology, as shown in the figure below.

Matrix of Possible Impacts

	Intended	**Unintended**
Positive Impacts		
Negative Impacts		

2. Students should discuss how some impacts may be indirect or delayed. Acid rain, or more correctly acid deposition, may affect people far from the source of the technology. Greenhouse gases, which have been accumulating since the beginning of the industrial period, may not show signs of effect until a future date. Students should provide examples of technology, both historical and current, and identify impacts within the matrix on the previous page.
3. The teacher should make the students aware that technology assessment often involves trade-offs with the development, selection, and use of all technologies. They occur within physical, informational, and biotechnologies. They also occur with other infrastructure technologies, such as energy and power distribution, and military technology. It is important for humans to examine these trade-offs during the design process—not after the technology is employed. Trade-offs occur with appropriate and conventional technology.
4. Students may discuss how technology assessment was considered in the past (as historic records show). This is not as detailed as today's technology assessments, however. The National Academy of Science was established in the U.S. in 1863 to look at scientific impacts, but did not equally look at social impacts. The Office of Technology Assessment was established in 1972, following many protests in the 1960s by individuals and groups concerned about the environment and health issues. The OTA was dismantled in 1995 for budgetary reasons; however, regional and state assessments are still performed.
5. The teacher may discuss the purposes of technology assessment, which may include (from Pytlik, 1978):
    - Identify existing or potential impacts of a technology device or process.
    - Identify, where possible, cause and effect relationships, direct or indirect.
    - Identify alternative technologies or processes for achieving the same goal.
    - Make estimates and comparisons of alternative technologies.
    - Present findings to those involved in decisions regarding the technology.
    - Identify areas that require further research.

Extension

1. Students, working in small groups, will select a technological issue, research the issues and alternatives, and examine potential positive and negative impacts.
2. Student groups will organize potential impacts into a table matrix, and identify areas that will require further research.
3. Student groups will analyze and present their findings to the class, including any limitations to their assessment.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, research, and presentation.

Additional Extension Activities

1. Students may apply this process to a local or regional issue, such as the development of a new highway and its alternative paths.
2. Guest speakers could be brought into the class from a variety of professions: engineers, legislators, community planners, etc.
3. Student work should be prominently displayed in the school for a period of time, or displayed at a community site.
4. Student presentations should be collated graphically or electronically for distribution.

Laboratory-Classroom Preparation
Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations.

Tools/Materials/Equipment
Research materials and Web access
Computers/software
Printers
Poster/sign maker

Laboratory-Classroom Safety and Conduct
Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class and show respect and appreciation for the efforts of others.

The assessment of technology is important for all technologies, from a student electric vehicle (foreground) to a major power plant (background).

Assignment – Lesson 5-3
Applying Technology Assessment Tools

Selecting a Technology

In small groups, select a technological issue. Look for a technology that may have significant impacts on one or more of the following: other humans or institutions, other organisms, or the environment. You may need to review several references to find the possible impacts, positive and negative, intended or unintended, as well as possible alternatives. Be sure to record the publishing information for each reference you use. A few technological issues are suggested on the next page.

Examining the Technological Issue

As you research your technology, record the impacts of each alternative using the following matrix. For each impact, indicate what was affected—humans, organisms, or the environment. The impacts can be technological, biological, or social. You may want to include notes for your analysis whether or not the impacts were delayed or indirect. The worksheet chart can be reproduced as needed.

Impacts Matrix

	Intended	Unintended
Positive Impacts	Notes here	
Negative Impacts		

Analysis

As you research, try to complete as much of the table as you can, with multiple entries in each of the four categories. Once you have exhausted your research, it is time to reflect upon your data and draw some conclusions. Will the technology have positive impacts that outweigh the negative impacts? (Careful, this may be hard to determine, as the positive and negative impacts may affect different people.) Will the intended outcomes be met, or did the technology fall short? Will the unintended impacts be serious enough to abandon the technology? Will the impacts be delayed or indirect?

Presentation

You may present the analysis in a variety of methods (check with your teacher). Be sure to include your references, as another student may want to do some further research on your technology.

Technology Assessment Trade-Off Issues

Technology Area	Trade-Off Issue
Medical and Health	1. Animal testing and new medicines. 2. Preventive versus prescriptive health care. 3. Artificial versus cadaver human part replacements. 4. Others:
Agriculture and Biotechnology	1. Pesticides, natural, or genetically engineered farming. 2. Genetically altered foods, risks versus benefits. 3. Stem cell research, risks versus benefits. 4. Others:
Information	1. Electronic record keeping and privacy issues. 2. Electronic media and copyrights. 3. Cable, phone, or satellite Internet service. 4. Use of toxic chemicals to produce information electronics 5. Others:
Construction	1. Private- or public funded sports complexes. 2. Alternative versus natural material use. 3. Manufactured versus on-site construction. 4. Others:
Manufacturing	1. Waste and pollution control of manufacturing plants. 2. Animal testing in product design. 3. Outsourcing of jobs and free trade. 4. Others:
Transportation	1. Developing new roads and eminent domain. 2. Public transport versus private ownership. 3. Energy use and pollution. 4. Others:
Energy and Power	1. Renewable versus non-renewable energy sources. 2. Large power plants versus local control. 3. Externalities and who pays for them. 4. Others:
Military	1. Fertilizers for farming or terrorist weapons. 2. Weapons of mass destruction, who can and cannot have them or develop them. 3. Development of chemical and biological weapons. 4. Others:
Others:	

Assignment Worksheet – Lesson 5-3

Student Name(s): **Technology:**

Date:

Brief Background
Provide a brief background of the technology (people, places, events, devices, etc.):
Describe each alternative.

Research (copy as needed, use one for each alternative, continue notes on additional pages)

Impacts Matrix: Alternative _____

	Intended	Unintended
Positive Impacts		
Negative Impacts		

Research Notes

Bibliography

Analysis Notes

Ideas for Presentation

Unit 5 – Lesson 4

Applying Forecasting/Futurology Tools

Lesson Duration: Six (6) hours.

STL Standards

- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (4)
- Students will develop an understanding of the role of society in the development and use of technology. (6)
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation and problem solving. (10)
- Students will develop the abilities to assess the impact of products and systems. (13)

STL Benchmarks

- Making decisions about technology involves weighing the trade-offs between the positive and negative effects. (4I)
- The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. (6I)
- Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. (10I)
- Technological problems must be researched before they can be solved. (10J)
- Collect information and evaluate its quality. (13J)
- Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment. (13K)
- Design forecasting techniques to evaluate the results of altering natural systems. (13M)

Learning Objectives

Upon completion of this lesson, students will be able to:

1. Define technology forecasting, and futurology, and provide multiple examples of each.
2. Examine the need of corporations and other economic enterprises for technology forecasting.
3. Describe multiple purposes of technology forecasting.
4. Examine various technology forecasting techniques and provide examples of their use.
5. Apply technology forecasting techniques to technological problems.
6. Describe limitations to technology forecasting.
7. Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population.
8. Use representations to model and interpret physical, social, and mathematical phenomena.
9. Understand that social and economic forces strongly influence which technologies will be developed and used, and will be affected by many factors, such as personal values, consumer acceptance, patent laws, the availability of risk capital, the federal budget, local and national regulations, media attention, economic competition, and tax incentives.
10. Recognize that, in deciding on proposals to introduce new technologies or curtail existing ones, some key questions arise concerning alternatives, risks, costs, and benefits.
11. Be aware, that when people try to prove a point, they may select only data that support it and ignore any that would contradict it.

Student Assessment Tools and/or Methods

Assessment Instrument – Quiz (See Appendix E for pre/post test.)
Directions: Select the response that best answers the question.
5-4A.
5-4B.
5-4C.
5-4D.
5-4E.

Assessment Instrument – Group Work

Category	Below Target	At Target	Above Target
Participation	Seldom participated. Did very little work.	Cooperative. Did his/her part of the work. Often offered useful ideas.	Always willing to do more. Routinely offered useful ideas.
Reliability	Did not have work done on time. Did not show up when the group met.	Group members could count on him/her.	Went beyond what was expected of him/her.
Attitude	Did not support group members. Did not share information. Had little interest in success of group.	Supported effort of others. Did not cause problems in the group.	Listened to and shared ideas with others. Was very self-directed.

Assessment Instrument – Research

Category	Below Target	At Target	Above Target
Variety of Sources	Use very little or varied sources.	Used multiple sources, with multiple perspectives.	Used many sources with a variety of viewpoints.
Documentation	Little or inadequate documentation.	All sources documented and done so properly.	Documentation well developed and referenced.
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented	Many areas explored, beyond base assignment, and well documented.

Assessment Instrument – Analysis/Presentation

Category	Below Target	At Target	Above Target
Thoroughness	Many areas not explored in the research, or not documented.	Most areas explored and well documented.	Many areas explored, beyond base assignment, and well documented.
Organization	Presentation not well organized and hard to follow.	Presentation well organized and easy to follow.	Presentation exceptionally well organized and flows very well.
Creativity	Presentation not very creative and somewhat boring.	Presentation creative, showing a good deal of planning.	Presentation extremely creative, showing a good deal of thought went into preparation.

Assessment Totals

ELEMENT	CRITERIA	POINTS POSSIBLE	EARNED ASSESSMENT	
			SELF	TEACHER
Quiz	As per above			
Group Work	As per above			
Research	As per above			
Analysis/Presentation	As per above			

Resource Materials

- Print-Based Sources
  - *Teaching the Future* (1976) Draper Kauffman Jr.
  - *Making Changes: A Futures Oriented Course in Inventive Problem Solving* (1981) John Thomas
  - *Megatrends: Ten New Directions Transforming Our Lives* ((1984) John Naisbitt
  - *Contemporary Technology* (1989) Linda Rae Markert
- Audiovisual Materials
  - *Race for the Future* – introduction to history and promise of solar and electric cars (bullfrogfilms.com)
  - *Velocity: Exploring Sustainability through Wind Power, Green Building and Hydrogen* (videoproject.com)
- Internet Sites
  - www.cpfonline.org/cpf/student_wheels.php – Web site to make futures wheels and look at other student's projects

Purpose of Lesson

To evaluate the process of technology forecasting, and apply forecasting tools to technological problems or situations.

Required Knowledge and/or Skills

Students should be able to identify future technological issues, research them, and apply futurology techniques to predict how they will be accepted or used.

Lesson 5-4:

Engagement

1. The teacher may begin by asking the students to predict what types of technology they may encounter in 5, 10, 20 or even 50 years in the future. They can discuss household gadgets and tools, transportation, communication, construction techniques, materials or structures, manufacturing techniques, biotechnologies, or others.
2. Students may discuss how art, entertainment, and literature, such as science fiction, are often used to predict the future. Students may present examples of each.
3. Students may discuss many daily examples of predicting the future, including sports events, stock market trends, political outcomes, or even the weather. Students should be able to provide many technological examples.

Exploration

1. Students will work in small groups to select and explore future possibilities with a new or upcoming technology.
2. Student groups will apply several futurology techniques to their selected technology.
3. Student groups will analyze their results and present them to the class.

Explanation

1. The teacher may provide examples of the most common types of prediction: systematic generation of alternatives, extrapolating trends, historical analysis and analogy, or collective opinion techniques.
2. The systematic generation of alternatives can be quantitative (like a mathematical computer program to predict economic futures) or qualitative, which is to say descriptive. Extrapolated trends look at current and past observations, determine how to weigh them, and develop alternatives. Historical trends are similar, but only rely on historical analysis, usually for the big picture. Collective opinion techniques can include the use of surveys, market research, or a Delphi technique that seeks to get consensus from a collection of experts.
3. The teacher will help groups select future technologies, develop questions for surveys and Delphi studies, and help groups organize information into a future wheel graphic model.

Extension

1. Students will work in small groups to select and explore a future technology and explore its future potential for success and/or level of acceptance.
2. Student groups will apply several futurology techniques to their selected technology, including a local survey and a Delphi survey with a selected group of experts.
3. Student groups will organize their information, and create a futures wheel as a graphic representation of their findings.
4. Student groups will present their findings to the class.

Evaluation

Students' knowledge, skills, and attitudes will be assessed using a quiz, and rubrics will be used for group work, research, and analysis/presentation.

Additional Extension Activities

1. Students may do several iterations of their Delphi study to improve its validity.
2. Students can research additional techniques to use on the same technology selected, or others as they are invented or innovated.
3. Student presentation should be prominently displayed in the school for a period of time.
4. Students may develop science fiction short stories based on the results of their study.
5. Student presentations can be collated into a graphic presentation, electronic storage, or Web site, for distribution.

Laboratory-Classroom Preparation

Students should have access to information gathering and research, room for small group and whole class discussion, and media and equipment for graphic production and presentations.

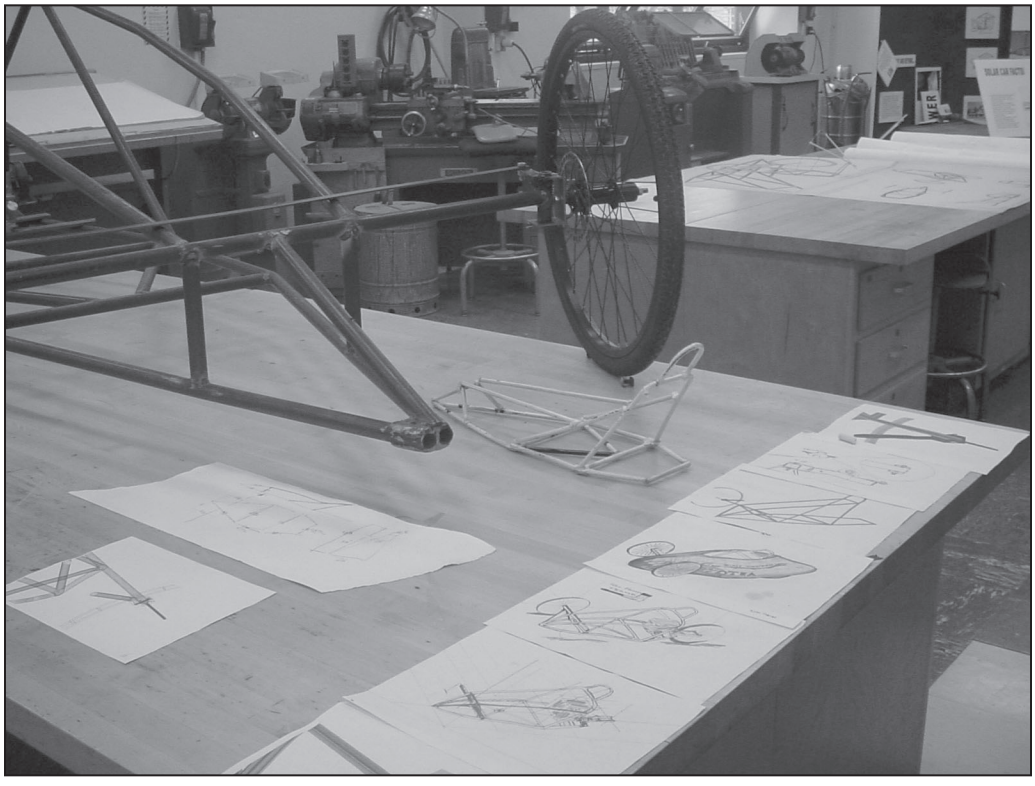
Tools/Materials/Equipment

Research materials and Web access
Computers/software
Printers
Poster/sign maker

Laboratory-Classroom Safety and Conduct

Students will use tools and equipment safely, maintaining a safety level for themselves and others in the lab.

Students will demonstrate respect and courtesy in regard to the ideas expressed by others in the class, and show respect and appreciation for the efforts of others.



Examining future transportation devices requires a look at various design concepts.

Assignment – Lesson 5-4
Applying Forecasting/Futurology Tools

Student Name(s): **Date:**

Selecting the Technological Problem

Select a current or emerging (future) technology device or process that is creating or will create technological issues. You will apply three futurology tools to the same technology. Be sure to record the publishing information for each reference you use. A few technology examples are provided here, and are categorized:

Information: data implant in humans, biometric security scanning, Internet evolution
Manufacturing: outsourcing jobs, solar power, scarcity of materials and water, nanotechnology
Transportation: alternative fuels, using nuclear power to make hydrogen, travel to Mars, automated cars/highways
Construction: using organisms for construction, smart houses, green buildings, space stations, colonization of other worlds
Biotechnology: artificial limbs or organs, cloning, stem cell research
Technology and Design: artificial intelligence, robots in the home, completely recyclable products

Technology selected: _____

Part One: Local Survey

Design a series of questions to ask about the future of your technology. In this part of the activity, you will be surveying peers, teachers, parents, and others in the community. You should generate 8-10 questions, each with several responses. Set up the survey (word-processed document) so the respondents will only need to circle their answers, making it easier to reply. Collate your answers into a table format and use that information for the next two parts and for your final presentation.

Part Two: Delphi Study

This survey is similar to the first, only in a Delphi you will need to survey experts in the field of the technology you are studying. First, locate, contact, and request the services of at least four experts in the field you are studying. For this activity, you will only be surveying them once, so when you contact them you can relate to them that you will require a minimum of time from their busy schedules. Typical Delphis use the results to resurvey the participants to see if they agree with their peers, and the survey is revised and sent out until some form of agreement is reached.

Next, develop a series of questions for your survey. You should develop 8-10 questions relating to the future of your selected technology. You will need to develop more technical and demanding questions than in Part One above, because in this survey you will be using experts, who already have some knowledge of the technology. This may take some research on your part; be sure to document all of your sources.

If you do not receive all of your surveys in a timely manner, send a kind reminder to the participants. You may wish to send all of your participants a copy of your conclusions. Collate your answers into a table format and use that information for the next part and for your final presentation.

Part Three: Futures Wheel

Based on your responses to both surveys and the results of your research, develop a futures wheel. A futures wheel is similar to the concept map you developed in Unit 1, Lesson 2. You will have your technology in the center of the futures wheel, and from there you connect the issues with primary, secondary, and tertiary causes and effects based on future predictions.

Use the space below (and additional if necessary) to develop ideas for your futures wheel.

Presentation

Develop a brief (5 minute) presentation using information from all three parts of this assignment. Be creative and concise. You may add your own predictions, based on all of your research and work. Use the space below to brainstorm and develop ideas for your presentation.

Appendices

Appendix A

Program Responsiblity Matrix - Technology/Science/Mathematics

		172	232	217	186	172	256	176	186	197	KEY: A: This standard/benchmark will be used to develop student understanding B: Conceptual understanding is transferable if supported C: Prior knowledge			
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The Nature of Technology														
STL-1	**Understanding the characteristics & scope of technology**	**8**	**12**	**11**	**16**	**9**	**8**	**11**	**10**	**11**				
A	The natural world and human-made world are different.	**4**												
B	All people use tools and techniques to help them do things.	**4**												
C	Things that are found in nature differ from things that are human-made in how they are produced and used.		**4**											
D	Tools, materials, and skills are used to make things and carry out tasks.		**4**											
E	Creative thinking and economic and cultural influences shape technological development.		**4**											
F	New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.			**4**	**4**	**4**								
G	The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.			**2**	**4**	**2**								
H	Technology is closely linked to creativity, which has resulted in innovation.			**3**	**4**									
I	Corporations can often create demand for a product by bringing it onto the market and advertising it.			**2**	**4**	**3**								
J	The nature and development of technological knowledge and processes are functions of the setting.						**2**	**3**		**4**				
K	The rate of technological development and diffusion is increasing rapidly.						**2**	**4**	**3**					
L	Inventions and innovations are the results of specific, goal-oriented research.						**2**	**2**	**3**	**4**	2/P	C		
M	Most development of technologies these days is driven by the profit motive and the market.						**2**	**2**	**4**	**3**			4F 6C, 6F	A
STL-2	**Understanding the core concepts of technology**	**20**	**28**	**13**	**29**	**35**	**21**	**14**	**20**	**23**				
A	Some systems are found in nature, and some are made by humans.	**4**												
B	Systems have parts or components that work together to accomplish a goal.	**4**												
C	Tools are simple objects that help humans complete tasks.	**4**												
D	Different materials are used in making things.	**4**												
E	People plan in order to get things done.	**4**												
F	A subsystem is a system that operates as a part of another system.		**4**											
G	When parts of a system are missing, it may not work as planned.		**4**											
H	Resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time.		**4**											
I	Tools are used to design, make, use, and assess technology.		**4**											
J	Materials have many different properties.		**4**											
K	Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing.		**4**											
L	Requirements are the limits to designing or making a product or system.		**4**											
M	Technological systems include input, processes, output, and, at times, feedback.			**4**	**4**	**4**								

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N	Systems thinking involves considering how every part relates to others.				3	4								
O	An open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.					4								
P	Technological systems can be connected to one another.			2	3	4								
Q	Malfunctions of any part of a system may affect the function and quality of the system.				4	4								
R	Requirements are the parameters placed on the development of a product or system.				4	4								
S	Trade-off is a decision process recognizing the need for careful compromises among competing factors.				4									
T	Different technologies involve different sets of processes.			2	4	3								
U	Maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its quality.			2	3	4								
V	Controls are mechanisms or particular steps that people perform using information about the system that causes systems to change.			3		4								
W	Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems.									4				
X	Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.						4		3				3N, P 14M, 22C	A
Y	The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.						3		3					
Z	Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.						3	3	3	2				
AA	Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.						3		3	4				
BB	Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.							2	2	4				
CC	New technologies create new processes.						4	2					6 C/6 D	A / B
DD	Quality control is a planned process to ensure that a product, service, or system meets established criteria.							4		4				
EE	Management is the process of planning, organizing, and controlling work.						4		3	2				
FF	Complex systems have many layers of controls and feedback loops to provide information.							3	3	3				
STL-3	**Understanding the relationships among technologies and connections with other fields of study**	**4**	**8**	**6**	**9**	**9**	**16**	**6**	**7**	**10**				
A	The study of technology uses many of the same ideas and skills as other subjects.	4												
B	Technologies are often combined.		4											
C	Various relationships exist between technology and other fields of study.		4											
D	Technological systems often interact with one another.			3	2	2								
E	A product, system, or environment developed for one setting may be applied to another setting.				4	3								
F	Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.			3	3	4								
G	Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.						4			4				

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H	Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.						**4**	**3**		**3**				
I	Technological ideas are sometimes protected through the process of patenting.						**4**		**3**	**3**				
J	Technological progress promotes the advancement of science and mathematics.						**4**	**3**	**4**		7/L	C		
Technology and Society														
STL-4	**Understanding the cultural, social, economic and political effects of technology**	**4**	**8**	**14**	**14**	**3**	**0**	**15**	**11**	**8**				
A	The use of tools and machines can be helpful or harmful.	**4**												
B	When using technology, results can be good or bad.		**4**											
C	The use of technology can have unintended consequences.		**4**											
D	The use of technology affects humans in various ways, including their safety, comfort, choices, and attitudes about technology's development and use.			**4**	**3**	**3**								
E	Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.			**4**	**3**									
F	The development and use of technology poses ethical issues.			**3**	**4**									
G	Economic, political, and cultural issues are influenced by the development and use of technology.			**3**	**4**									
H	Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.							**4**						
I	Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.							**4**	**3**	**3**	9/S, U	A		
J	Ethical considerations are important in the development, selection, and use of technologies.							**3**	**4**	**3**	9/S, T	B		
K	The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.							**4**	**4**	**2**	9/Q , R	A		
STL-5	**Understanding the effects of technology on the environment**	**4**	**8**	**8**	**4**	**9**	**4**	**21**	**19**	**11**				
A	Some materials can be reused and/or recycled.	**4**												
B	Waste must be appropriately recycled or disposed of to prevent unnecessary harm to the environment.		**4**											
C	The use of technology affects the environment in good and bad ways.		**4**											
D	The management of waste produced by technological systems is an important societal issue.			**4**		**3**								
E	Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.				**1**	**4**								
F	Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another.			**4**	**3**	**2**								
G	Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.							**4**	**3**	**2**				
H	When new technologies are developed to reduce the use of resources, considerations of trade-offs are important.							**3**	**4**				6 C,F 22C	A
I	With the aid of technology, various aspects of the environment can be monitored to provide information for decision making.							**3**	**4**				14 H, I, M	A

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J	The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.							**4**		**3**				
K	Humans devise technologies to reduce the negative consequences of other technologies.						**4**	**3**	**4**	**3**				
L	Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment.							**4**	**4**	**3**	9/S, 21/L 33/J, 62/H	A,C,B,C	16 H	A
STL-6	**Understanding the role of society in the development and use of technology**	**4**	**8**	**13**	**15**	**2**	**5**	**3**	**11**	**9**				
A	Products are made to meet individual needs and wants.	**4**												
B	Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes.		**4**											
C	Individual, family, community, and economic concerns may expand or limit the development of technologies.		**4**											
D	Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.			**4**	**3**									
E	The use of inventions and innovations has led to changes in society and the creation of new needs and wants.			**3**	**4**									
F	Social and cultural priorities and values are reflected in technological devices.			**3**	**4**	**2**								
G	Meeting societal expectations is the driving force behind the acceptance and use of products and systems.			**3**	**4**									
H	Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values.						**2**		**3**	**3**				
I	The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures.							**3**	**4**	**3**	3/S, 9/S	B	14 I	A
J	A number of different factors, such as advertising, the strength of the economy, the goals of a company, and the latest fads contribute to shaping the design of and demand for various technologies.						**3**		**4**	**3**			16 H	B
STL-7	**Understanding the influence of technology on history**	**4**	**4**	**6**	**14**	**4**	**27**	**20**	**15**	**4**				
A	The way people live and work has changed throughout history because of technology.	**4**												
B	People have made tools to provide food, to make clothing, and to protect themselves.		**4**											
C	Many inventions and innovations have evolved by using slow and methodical processes of tests and refinements.			**3**	**4**									
D	The specialization of function has been at the heart of many technological improvements.			**3**	**4**									
E	The design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.				**2**	**4**								
F	In the past, an invention or innovation was not usually developed with the knowledge of science.				**4**									
G	Most technological development has been evolutionary, the result of a series of refinements to a basic invention.						**4**			**2**	3/N, O, P	C		
H	The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials.							**4**	**3**	**1**	8/K	C		
I	Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.							**4**	**3**	**1**	8/K	C		
J	Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how.						**4**		**2**		8/K	C		

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K	The Iron Age was defined by the use of iron and steel as the primary materials for tools.						**4**		**3**					
L	The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society.						**4**	**3**						
M	The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology.						**4**	**3**						
N	The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time.						**4**	**3**						
O	The Information Age places emphasis on the processing and exchange of information.						**3**	**3**	**4**		8/K	C		
Design														
STL-8	**Understanding the attributes of design**	**8**	**8**	**9**	**12**	**0**	**13**	**2**	**8**	**15**				
A	Everyone can design solutions to a problem.	**4**												
B	Design is a creative process.	**4**												
C	The design process is a purposeful method of planning practical solutions to problems.		**4**											
D	Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.		**4**											
E	Design is a creative planning process that leads to useful products and systems.			**3**	**4**									
F	There is no perfect design.			**3**	**4**									
G	Requirements for a design are made up of criteria and constraints.			**3**	**4**									
H	The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.						**4**	**2**	**2**	**4**	8/M	B		
I	Design problems are seldom presented in a clearly defined form.						**3**		**3**	**3**				
J	The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.						**3**			**4**				
K	Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.						**3**		**3**	**4**				
STL-9	**Understanding engineering design**	**8**	**12**	**10**	**11**	**2**	**13**	**0**	**2**	**16**				
A	The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.	**4**												
B	Expressing ideas to others verbally and through sketches and models is an important part of the design process.	**4**												
C	The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.		**4**											
D	When designing an object, it is important to be creative and consider all ideas.		**4**											
E	Models are used to communicate and test design ideas and processes.		**4**											
F	Design involves a set of steps, which can be performed in different sequences and repeated as needed.			**4**	**4**									

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N	The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time.						**4**	**3**						
O	The Information Age places emphasis on the processing and exchange of information.						**3**	**3**	**4**		8/K	C		
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G	Requirements for a design are made up of criteria and constraints.			**3**	**4**									
H	The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.						**4**	**2**	**2**	**4**	8/M	B		
I	Design problems are seldom presented in a clearly defined form.						**3**		**3**	**3**				
J	The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.						**3**			**4**				
K	Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.						**3**		**3**	**4**				
STL-9	**Understanding engineering design**	**8**	**12**	**10**	**11**	**2**	**13**	**0**	**2**	**16**				
A	The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.	**4**												
B	Expressing ideas to others verbally and through sketches and models is an important part of the design process.	**4**												
C	The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.		**4**											
D	When designing an object, it is important to be creative and consider all ideas.		**4**											
E	Models are used to communicate and test design ideas and processes.		**4**											
F	Design involves a set of steps, which can be performed in different sequences and repeated as needed.			**4**	**4**									

Appendix A

Program Responsiblity Matrix - Technology/Science/Mathematics

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G	Improve the design solutions.		**4**											
H	Apply a design process to solve problems in and beyond the laboratory-classroom.			**3**	**4**									
I	Specify criteria and constraints for the design.			**3**	**4**									
J	Make two-dimensional and three-dimensional representations of the designed solution.			**3**	**4**									
K	Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.			**3**	**4**									
L	Make a product or system and document the solution.			**3**	**4**	**2**								
M	Identify the design problem to solve and decide whether or not to address it.						**4**	**2**	**3**	**4**	8/J	B		
N	Identify criteria and constraints and determine how these will affect the design process.						**4**		**3**	**3**				
O	Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.						**4**			**3**				
P	Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.						**4**			**3**				
Q	Develop and produce a product or system using a design process.						**4**			**3**				
R	Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.						**4**			**3**				
STL-12	**Abilities to use and maintain technological products and systems**	**12**	**16**	**8**	**9**	**13**	**13**	**7**	**1**	**15**				
A	Discover how things work.	**4**												
B	Use hand tools correctly and safely and be able to name them correctly.	**4**												
C	Recognize and use everyday symbols.	**4**												
D	Follow step-by-step directions to assemble a product.		**4**											
E	Select and safely use tools, products, and systems for specific tasks.		**4**											
F	Use computers to access and organize information.		**4**											
G	Use common symbols, such as numbers and words, to communicate key ideas.		**4**											
H	Use information provided in manuals, protocols, or by experienced people to see and understand how things work.			**4**	**3**	**3**								
I	Use tools, materials, and machines safely to diagnose, adjust, and repair systems.				**3**	**4**								
J	Use computers and calculators in various applications.			**4**	**3**	**2**								
K	Operate and maintain systems in order to achieve a given purpose.					**4**								
L	Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.						**3**	**4**	**1**	**3**	65/L&M 65/P&Q	C		
M	Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.						**3**			**3**				
N	Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision.									**3**				
O	Operate systems so that they function in the way they were designed.						**3**			**3**				

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P	Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate						**4**	**3**		**3**				
STL-13	**Abilities to assess the impact of products and systems**	**8**	**12**	**9**	**6**	**16**	**3**	**15**	**10**	**9**				
A	Collect information about everyday products and systems by asking questions.	**4**												
B	Determine if the human use of a product or system creates positive or negative results.	**4**												
C	Compare, contrast, and classify collected information in order to identify patterns.		**4**											
D	Investigate and assess the influence of a specific technology on the individual, family, community, and environment.		**4**											
E	Examine the trade-offs of using a product or system and decide when it could be used.		**4**											
F	Design and use instruments to gather data.			**3**		**4**								
G	Use data collected to analyze and interpret trends in order to identify the positive or negative effects of a technology.				**3**	**4**								
H	Identify trends and monitor potential consequences of technological development.			**3**		**4**								
I	Interpret and evaluate the accuracy of the information obtained and determine if it is useful.			**3**	**3**	**4**								
J	Collect information and evaluate its quality.						**3**	**3**	**4**	**3**	41/J, K	C	12 M 14 H	A
K	Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment.							**4**	**3**	**2**	33/K, L	C	22 A-C	A
L	Use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology.							**4**		**2**	66/N	C	6 C,D,F	A
M	Design forecasting techniques to evaluate the results of altering natural systems.							**4**	**3**	**2**			16 I	B
The Designed World														
STL-14	**Understanding of and abilities to select and use medical technologies**	**12**	**12**	**13**	**4**	**8**	**4**	**9**	**8**	**0**				
A	Vaccinations protect people from getting certain diseases.	**4**												
B	Medicine helps people who are sick to get better.	**4**												
C	There are many products designed specifically to help people take care of themselves.	**4**												
D	Vaccines are designed to prevent diseases from developing and spreading; medicines are designed to relieve symptoms and stop diseases from developing.		**4**											
E	Technological advances have made it possible to create new devices, to repair or replace certain parts of the body, and to provide a means for mobility.		**4**											
F	Many tools and devices have been designed to help provide clues about health and to provide a safe environment.		**4**											
G	Advances and innovations in medical technologies are used to improve health care.			**3**	**4**									
H	Sanitation processes used in the disposal of medical products help to protect people from harmful organisms and disease, and shape the ethics of medical safety.			**4**										
I	The vaccines developed for use in immunization require specialized technologies to support environments in which a sufficient amount of vaccines are produced.			**3**		**4**								

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J	Genetic engineering involves modifying the structure of DNA to produce novel genetic make-ups.			3		4								
K	Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained.						4	3						
L	Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology.							3	4		42/G, M	B		
M	The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures.							3	4		19/K, L, M	C		
STL-15	**Understanding of and abilities to select and use agricultural and biotechnologies**	**8**	**12**	**16**	**0**	**4**	**4**	**4**	**14**	**3**				
A	The use of technologies in agriculture makes it possible for food to be available year round and to conserve resources.	4												
B	There are many different tools necessary to control and make up the parts of an ecosystem.	4												
C	Artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals.		4											
D	Most agricultural waste can be recycled.		4											
E	Many processes used in agriculture require different procedures, products, or systems.		4											
F	Technological advances in agriculture directly affect the time and number of people required to produce food for a large population.			4										
G	A wide range of specialized equipment and practices is used to improve the production of food, fiber, fuel, and other useful products and in the care of animals.					4								
H	Biotechnology applies the principles of biology to create commercial products or processes.			4										
I	Artificial ecosystems are human-made complexes that replicate some aspects of the natural environment.			4										
J	The development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food.			4										
K	Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products.								3		37/P	C		
L	Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering.						4		3					
M	Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.							4	4					
N	The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna.								4	3				
STL-16	**Understanding of and abilities to select and use energy and power technologies**	**8**	**8**	**14**	**2**	**8**	**20**	**6**	**3**	**6**				
A	Energy comes in many forms.	4												
B	Energy should not be wasted.	4												
C	Energy comes in different forms.		4											
D	Tools, machines, products, and systems use energy in order to do work.		4											
E	Energy is the capacity to do work.			4										

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F	Energy can be used to do work, using many processes.			**2**		**4**								
G	Power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done.			**4**										
H	Power systems are used to drive and provide propulsion to other technological products and systems.				**2**	**4**								
I	Much of the energy used in our environment is not used efficiently.			**4**										
J	Energy cannot be created nor destroyed; however, it can be converted from one form to another.						**4**							
K	Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.						**4**							
L	It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings.						**4**	**4**						
M	Energy resources can be renewable or nonrenewable.						**4**	**2**	**3**	**3**	22/J 33/P, Q	B		
N	Power systems must have a source of energy, a process, and loads.						**4**			**3**				
STL-17	**Understanding of and abilities to select and use information and communication technologies**	**12**	**16**	**13**	**4**	**11**	**23**	**6**	**4**	**7**				
A	Information is data that has been organized.	**4**												
B	Technology enables people to communicate by sending and receiving information over a distance.	**4**												
C	People use symbols when they communicate by technology.	**4**												
D	The processing of information through the use of technology can be used to help humans make decisions and solve problems.		**4**											
E	Information can be acquired and sent through a variety of technological sources, including print and electronic media.		**4**											
F	Communication technology is the transfer of messages among people and/or machines over distances through the use of technology.		**4**											
G	Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations.		**4**											
H	Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human.			**3**		**4**								
I	Communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination.			**3**		**4**								
J	The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.			**4**										
K	The use of symbols, measurements, and drawings promotes clear communication by providing a common language to express ideas.			**3**	**4**	**3**								
L	Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information.						**4**			**2**				
M	Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.						**4**							
N	Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.						**3**	**3**	**4**		24/N 47/J, K	C		
O	Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.						**4**							
P	There are many ways to communicate information, such as graphic and electronic means.						**4**	**3**		**2**			6 C	A

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Q	Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.						4			3				
STL-18	**Understanding of and abilities to select and use transportation technologies**	**12**	**8**	**4**	**3**	**15**	**8**	**12**	**8**	**3**				
A	A transportation system has many parts that work together to help people travel.	4												
B	Vehicles move people or goods from one place to another in water, air, or space and on land.	4												
C	Transportation vehicles need to be cared for to prolong their use.	4												
D	The use of transportation allows people and goods to be moved from place to place.		4											
E	A transportation system may lose efficiency or fail if one part is missing or malfunctioning or if a subsystem is not working.		4											
F	Transporting people and goods involves a combination of individuals and vehicles.			4		3								
G	Transportation vehicles are made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively.					4								
H	Governmental regulations often influence the design and operation of transportation systems.				3	4								
I	Processes, such as receiving, holding, storing, loading, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently.					4								
J	Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.						4	3						
K	Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another.						4	3	2					
L	Transportation services and methods have led to a population that is regularly on the move.							2	4					
M	The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques.							4	2	3				
STL-19	**Understanding of and abilities to select and use manufacturing technologies**	**8**	**12**	**16**	**4**	**4**	**18**	**19**	**6**	**11**				
A	Manufacturing systems produce products in quantity.	4												
B	Manufactured products are designed.	4												
C	Processing systems convert natural materials into products.		4											
D	Manufacturing processes include designing products, gathering resources, and using tools to separate, form, and combine materials in order to produce products.		4											
E	Manufacturing enterprises exist because of a consumption of goods.		4											
F	Manufacturing systems use mechanical processes that change the form of materials through the processes of separating, forming, combining, and conditioning.			4										
G	Manufactured goods may be classified as durable and non-durable.			4										
H	The manufacturing process includes the designing, development, making, and servicing of products and systems.					4								
I	Chemical technologies are used to modify or alter chemical substances.			4										
J	Materials must first be located before they can be extracted from the earth through such processes as harvesting, drilling, and mining.			4										

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K	Marketing a product involves informing the public about it well as assisting in selling and distributing it.				**4**									
L	Servicing keeps products in good operating condition.							**4**						
M	Materials have different qualities and may be classified as natural, synthetic, or mixed.						**4**	**3**		**4**	17/L 38/P	B		
N	Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time.						**4**	**2**	**2**	**2**				
O	Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production.						**4**		**2**		38/M	C		
P	The interchangeability of parts increases the effectiveness of manufacturing processes.						**2**	**4**		**3**				
Q	Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products.							**4**						
R	Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it.						**4**	**2**	**2**	**2**				
STL-20	**Understanding of and abilities to select and use construction technologies**	**8**	**12**	**10**	**0**	**12**	**20**	**4**	**8**	**8**				
A	People live, work, and go to school in buildings, which are of different types: houses, apartments, office buildings, and schools.	**4**												
B	The type of structure determines how the parts are put together	**4**												
C	Modern communities are usually planned according to guidelines.		**4**											
D	Structures need to be maintained.		**4**											
E	Many systems are used in buildings.		**4**											
F	The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function.			**4**										
G	Structures rest on a foundation.			**3**		**4**								
H	Some structures are temporary, while others are permanent.			**3**		**4**								
I	Buildings generally contain a variety of subsystems.					**4**								
J	Infrastructure is the underlying base or basic framework of a system.						**4**	**2**		**2**				
K	Structures are constructed using a variety of processes and procedures.						**4**		**3**					
L	The design of structures includes a number of requirements.						**4**		**3**	**3**				
M	Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use.						**4**	**2**		**3**				
N	Structures can include prefabricated materials						**4**		**2**					

Appendix B

Mathematics Standards from National Council of Teachers of Mathematics (NCTM): Technological Issues

NUMBERS AND OPERATIONS

1. Understand numbers, ways of representing numbers, relationships among numbers, and number systems
   - N work flexibly with fractions, decimals, and percents to solve problems
   - Q understand and use ratios and proportions to represent quantitative relationships
   - R develop an understanding of large numbers and recognize and appropriately use exponential, scientific, and calculator notation
3. Compute fluently and make reasonable estimates
   - N develop, analyze, and explain methods for solving problems involving proportions, such as scaling and finding equivalent ratios.
   - P judge the reasonableness of numerical computations and their results

ALGEBRA

4. Understand patterns, relations, and functions
   - F represent, analyze, and generalize a variety of patterns with tables, graphs, words, and, when possible, symbolic rules
6. Use mathematical models to represent and understand quantitative relationships
   - C model and solve contextualized problems using various representations, such as graphs, tables, and equations
   - F draw reasonable conclusions about a situation being modeled

MEASUREMENT STANDARD

12. Understand measurable attributes of objects and the units, systems, and processes of measurement
    - M make decisions about units and scales that are appropriate for problem situations involving measurement
13. Apply appropriate techniques, tools, and formulas to determine measurements.
    - Q solve problems involving scale factors, using ratio and proportion

DATA ANALYSIS AND PROBABILITY

14. Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.
    - H formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population
    - J understand the differences among various kinds of studies and which types of inferences can legitimately be drawn from each

PROCESS STANDARDS

18. Problem Solving
    - A Build new mathematical knowledge through problem solving
20. Communication
    - B Communicate their mathematical thinking coherently and clearly to peers, teachers, and others
21. Connections
    - C Recognize and apply mathematics in contexts outside of mathematics
22. Representation
    - A Create and use representations to organize, record, and communicate mathematical ideas
    - C Use representations to model and interpret physical, social, and mathematical phenomena

Science Standards from American Association for the Advancement of Science: Technological Issues

THE NATURE OF SCIENCE (Chapter 1)

The Scientific Enterprise (1C)

3P Progress in science and invention depends heavily on what else is happening in society, and history often depends on scientific and technological developments.

THE NATURE OF TECHNOLOGY (Chapter 3)

Technology and Science (3A)

7K Technological problems often create a demand for new scientific knowledge, and new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research.

Design and Systems (3B)

8J In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.

8K The value of any given technology may be different for different groups of people and at different points in time.

8M Risk analysis is used to minimize the likelihood of unwanted side effects of a new technology. The public perception of risk may depend, however, on psychological factors as well as scientific ones.

Issues in Technology (3C)

9Q Social and economic forces strongly influence which technologies will be developed and used. Which will prevail is affected by many factors, such as personal values, consumer acceptance, patent laws, the availability of risk capital, the federal budget, local and national regulations, media attention, economic competition, and tax incentives.

9S In deciding on proposals to introduce new technologies or to curtail existing ones, some key questions arise concerning alternatives, risks, costs, and benefits.

9U Human inventiveness has brought new risks as well as improvements to human existence.

THE LIVING ENVIRONMENT (Chapter 5)

Heredity (5B)

19K Genes are segments of DNA molecules. Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment.

Interdependence of Life (5D)

21L Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.

Flow of Matter and Energy (5E)

22J The amount of life any environment can support is limited by the available energy, water, oxygen, and minerals, and by the ability of ecosystems to recycle the residue of dead organic materials. Human activities and technology can change the flow, and technology can change the flow and reduce the fertility of the land.

THE HUMAN ORGANISM (Chapter 6)

Human Identity (6A)

24N Written records and photographic and electronic devices enable human beings to share, compile, use, and misuse great amounts of information and misinformation. No other species uses such technologies.

HUMAN SOCIETY (Chapter 7)

Social trade-Offs (7D)

33K In deciding among alternatives, a major question is who will receive the benefits and who (not necessarily the same people) will bear the costs.

THE DESIGNED WORLD (Chapter 8)

Agriculture (8A)

37P Agricultural technology requires tradeoffs between increased production and environmental harm and between efficient production and social values. In the past century, agricultural technology led to a huge shift of population from farms to cities and a great change in how people live and work.

Materials and Manufacturing (8B)

38N Waste management includes considerations of quantity, safety, degradability, and cost. It requires social and technological innovations, because waste-disposal problems are political and economic as well as technical.

Energy Sources and Use (8C)

39P Industrialization brings an increased demand for and use of energy. Such usage contributes to the high standard of living in the industrially developing nations but also leads to more rapid depletion of the earth's energy resources and to environmental risks associated with the use of fossil and nuclear fuels.

39Q Decisions to slow the depletion of energy sources through efficient technology can be made at many levels, from personal to national, and they always involve tradeoffs of economic costs and social values.

Information Processing (8E)

41J Computer modeling explores the logical consequences of a set of instructions and a set of data. The instructions and data input of a computer model try to represent the real world so the computer can show what would actually happen.

Health technology (8F)

42M Biotechnology has contributed to health improvement in many ways, but its cost and application have led to a variety of controversial social and ethical issues.

COMMON THEMES (Chapter 11)

Systems (11A)

58J Understanding how things work and designing solutions to problems of almost any kind can be facilitated by systems analysis. In defining a system, it is important to specify its boundaries and subsystems, indicate its relation to other systems, and identify what its input and output are expected to be.

HABITS OF MIND (Chapter 12)

Values and Attitudes (12A)

62H View science and technology thoughtfully, being neither categorically antagonistic nor uncritically positive.

Communication Skills (12D)

65Q Use tables, charts, and graphs in making arguments and claims in oral and written presentations.

Critical-Response Skills (12E)

66N Be aware, when considering claims, that when people try to prove a point, they may select only the data that support it and ignore any that would contradict it.

Appendix C
References and Suggested Readings

The following readings are either quoted or are suggested to provide the teacher with additional background information. Some of the following publications may be out of print, but are considered classics on the topics they present. Some of those titles can be purchased online at discount book sites.

Preface/Introduction

American Association for the Advancement of Science (1993). *Benchmarks for science literacy*. New York: Oxford University Press.*

International Technology Education Association. (2002). *Measuring Progress: A guide to assessing students for technological literacy*. Reston, VA: Author.

International Technology Education Association. (2000/2002). *Standards for technological literacy: Content for the study of technology*. Reston, VA: Author.

National Academy of Engineering/National Research Council. (2002). *Technically speaking: Why all Americans need to know more about technology*. Washington, DC: National Academy Press.

National Center for the Teaching of Mathematics (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

* Publication can be viewed online at: www.project2061.org/tools/benchol/bolframe.htm

Chapter One

Alcorn, P. (1986). *Social issues in technology: a format for investigation*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Burke, J. (1985). *The day the universe changed*. Boston: Little, Brown & Co.

Burke (1995). *Connections*. Revised Edition. Boston: Little, Brown & Co.

Gomez, A., et. al. (2004). *Engineering your future: a project based introduction to engineering*. St. Louis: Great Lakes Press, Inc.

Karwatka, D. (1996). *Technology's past: America's Industrial Revolution and the people who delivered the goods*. Ann Arbor, MI: Prakken Publications, Inc.

Kranzberg, M. & Pursell, C.W. Jr., Editors. (1967). *Technology in western civilization*. New York: Oxford University Press.

Lewis, H. W. (1990). *Technological risk*. New York: W. W. Norton & Co.

McClellan, J., III (1999). *Science and technology in world history*. Baltimore: John Hopkins university Press.

Pytlik, E. et.al. (1978). *Technology, change and society*. Worcester, MA: Davis Publications, Inc.

Rogers, E. (1995). *Diffusion of innovations*. 4th Edition. New York: Free Press

Williams, T. (1987). *The history of invention: from stone axes to silicon chips*. New York: Facts on File Publications.

Voland, G. (1999). *Engineering by design*. Reading, MA: Addison-Wesley.

Chapter Two

Brown, L. (1981). *Building a sustainable society*. New York: W. W. Norton & Company.

Council on Technology Teacher Education. (1996). *Technology and the quality of life*. New York: McGraw Hill/Glencoe.

Lovins, A. (1977). *Soft energy paths: toward a durable peace*. New York: Harper Colophon Books.

Meadows, D. et. al. (1972). *The limits to growth*. New York: Universe Books.

Markert, L. R. (1989). *Contemporary technology: innovations, issues, and perspectives*. South Holland, IL: Goodheart-Wilcox Co., Inc.

Petroski, H. (1994). *Design paradigms: case histories of error and judgment in engineering*. New York: Cambridge University Press.

Sale, K. (1980). *Human scale*. New York: Coward, McCann & Geoghegan.

Schumacher, E. (1973). *Small is beautiful: economics as if people mattered.* New York: Harper & Row, Publishers.

Todd, R., et.al. (1996). *Introduction to design and technology*. Cincinnati: Thomson Learning Tools.

Voland, G. (1999). *Engineering by design*. Reading, MA: Addison-Wesley.

Worldwatch Institute**. (2003). *State of the world 2003: a Worldwatch Institute report on progress toward a sustainable society*. New York: W. W. Norton & Company.
** The Worldwatch Institute produces this report annually on global issues. It also has many smaller, specific reports. Its reports of more than 18 months are available online for free downloading. Materials available at their Web site: www.worldwatch.org

Chapter Three

Brower, M. & Leon, W. (1999). *The consumer's guide to effective environmental choices*. New York: Three Rivers Press.

Council on Technology Teacher Education. (1996). *Technology and the quality of life*. New York: McGraw Hill/Glencoe.

Council on Technology Teacher Education. (2004). *Ethics for citizenship in a technological world*. New York: McGraw Hill/Glencoe.

Dul, J. & Weerdmeester, B. (2001). *Ergonomics for beginners: a quick reference guide*. 2nd Edition. Boca Raton, FL: CRC Press

Johnson, D. (1991). *Ethical issues in engineering*. Englewood Cliffs, NJ: Prentice Hall.

McDonough, W. & Braungart, M. (2002) *Cradle to cradle: remaking the way we make things*. New York: North Point Press.

Oaks, W. et. al. (2004). *Engineering your future: an introduction to engineering.* 4th Edition. St. Louis: Great Lakes Press, Inc.

Papanek, V. (1985). *Design for the real world: human ecology and social change*. 2nd Edition. Chicago: Academy Chicago Publishers.

Phillips, J. (2004) *Product liability: in a nutshell*. St. Paul, MN: West Publishing Co.

Ulrich, K. & Eppinger, S. (2003). *Product design and development*. New York: McGraw-Hill/Irvin.

Voland, G. (1999). *Engineering by design*. Reading, MA: Addison-Wesley.

Worldwatch Institute**. (2003). *State of the world 2003*: *a Worldwatch Institute report on progress toward a sustainable society*. New York: W. W. Norton & Company.

Chapter Four

Alcorn, P. (1986). *Social issues in technology: a format for investigation*. Englewood Cliffs, NJ: Prentice-Hall Inc.

Brown, L. (1981). *Building a sustainable society*. New York: W. W. Norton & Company.

Carr, M. (1985). *The appropriate technology reader: theory and practice in appropriate technology*. New York: Intermediate Technology Development Group of North America.

Council on Technology Teacher Education. (2001). *Appropriate technology for sustainable living*. New York: McGraw Hill/Glencoe.

Council on Technology Teacher Education. (1996). *Technology and the quality of life*. New York: McGraw Hill/Glencoe.

Easton, T. (2005). *Taking sides: clashing views on controversial issues in science, technology and society*. 6th Edition. Dubuque, IO: McGraw Hill/Dushkin.

Flack, J. (1989). *Inventing, inventors and inventions: a teaching resource book*. Portsmouth, NH: Teacher Ideas Press.

Grace, E. (1997). *Biotechnology unzipped: Promises & realities*. Washington, D C: Joseph Henry Press.

Hazeltine, B. ed. (2003). *Field guide to appropriate technology*. San Diego, CA: Academic Press.

Hider, G. (1992). *The appropriate technology approach*. In A. F. Gilberti (Ed.), *Integrating technology, people and the environment*. Reston, VA: International Technology Education Association.

International Technology Education Association. (2004). *Innovation and invention: a standards-based middle school model course guide*.. Reston, VA: Author.

Lovins, A. (1977). *Soft energy paths: toward a durable peace*. New York: Harper Colophon Books.

Sale, K. (1980). *Human scale*. New York: Coward, McCann & Geoghegan.

Schaeffer, J. (2005). *Solar living source book: your complete guide to renewable energy and sustainable living*. 12th Edition. Hopland, CA: Gaiam Real Goods.

Schumacher, E. (1973). *Small is beautiful: economics as if people mattered*. New York: Harper & Row, Publishers.

Stokes, B. (1981). *Helping Ourselves: Local solutions to global problems*. New York: W. W. Norton & company.

Todd, R., et.al. (1996). *Introduction to design and technology*. Cincinnati: Thomson Learning Tools.

Ulrich, K. & Eppinger, S. (2003). *Product design and development*. New York: McGraw-Hill/Irvin.

Voland, G. (1999). *Engineering by design*. Reading, MA: Addison-Wesley.

Chapter Five

Alcorn, P. (1986). *Social issues in technology: a format for investigation*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Easton, T. (2005). *Taking sides: clashing views on controversial issues in science, technology and society*. 6th Edition. Dubuque, IA: McGraw Hill/Dushkin.

Kauffman, D. L. Jr. (1976). *Teaching the future: a guide to future-orientated education*. Palm Springs, CA: ETC Publications.

Markert, L. R. (1989). *Contemporary technology: innovations, issues, and perspectives*. South Holland, IL: Goodheart-Wilcox Co., Inc.

McDonough, W. & Braungart, M. (2002) *Cradle to cradle: remaking the way we make things*. New York: North Point Press.

Naisbett, J. (1984). *Megatrends: ten new directions transforming our lives*. New York: Warner Books.

Pytlik, E., et.al. (1978). *Technology, change and society*. Worcester, MA: Davis Publications, Inc.

Thomas, J.W. (1981). *Making changes: a futures oriented course in inventive problem solving*. Palm Springs, CA: ETC Publications.

Ulrich, K. & Eppinger, S. (2003) *Product design and development*. New York: McGraw-Hill/Irvin.

Voland, G. (1999). *Engineering by design*. Reading, MA: Addison-Wesley.

Appendix D
Glossaries

Acceptable Evidence Glossary

Adequately – Sufficient for a specific requirement; also, barely sufficient or satisfactory.

Clearly – In a clear manner (easily heard, easily visible, free from obscurity or ambiguity, easily understood, unmistakable).

Correctly – 1. Conforming to an approved or conventional standard. 2. Conforming to or agreeing with fact, logic, or known truth. 3. Conforming to a set figure. 4. Conforming to the strict requirements of a specific ideology.

Create – 1. To make or bring into existence something new. 2. To invest with a new form, office, or rank; to produce or bring about through a course of action or behavior. 3. Cause, occasion. 4. To produce, through imaginative skill; to design.

Creatively – 1. The quality of being creative. 2. The ability to create.

Effectively – In an effective manner (producing a decided, decisive effect [result]).

Efficiently – Producing desired effects; productive without waste.

Insightfully – Exhibiting or characterized by insight (the power or act of seeing into a situation; the act or result of apprehending the inner nature of things or of seeing intuitively).

Introspectively – Behaving with introspection (a reflective looking inward; an examination of one's own thoughts and feelings).

Logically – Employing or behaving in accordance with logic (capable of reasoning or of using reason in an orderly, cogent fashion).

Marginally – Close to the lower limit of qualification, acceptability, or function; barely exceeding the minumum requirements.

Meaningfully – 1. Having meaning or purpose; full of meaning, significant.

Mimimally – Relating to or being a minimum: the least possible; barely adequate.

Mostly – For the greatest part; mainly.

Randomly – 1. Lacking a definite plan, purpose, or pattern. 2. Being or relating to a set (or to an element of a set) each of whose elements has equal probability of occurrence.

Safely – Free from harm or risk; unhurt; secure from threat or danger, harm, or loss; affording safety or security from danger, risk, or difficulty.

Systematically – 1. Presented or formatted as a coherent body of ideas or principles. 2. Methodical in procedure or plan; marked by thoroughness and regularity.

Thoroughly – 1. Carried through to completion. 2. Marked by full detail; painstaking; complete in all respects.

Thoughtfully – 1. Absorbed in thought. 2. Characterized by careful reasoned thinking. 3. Given to or chosen or made with heedful anticipation of the needs and wants of others.

Technological Issues Glossary

Acid rain – Rain (or other precipitation) that has an acidic pH (lower than 7) due to pollutants, usually from the burning of fossil fuels, and have the potential to cause environmental damage.

Administrators – Those professionals who manage any aspect of the educational system, including supervisors or teachers as appropriate.

Advisory committee – An organized body comprised of informed and qualified individuals with a specified responsiblity to give advice in the development of an idea or process. Members may include parents, business and industry personnel, local engineers, technologists, and interested citizens.

Affective – Relating to, arising from, or influencing feelings or emotions.

Agriculture – The process of raising crops and animals for food, feed, fibre, fuel, or other useful products.

Agroforestry – Land management for the simultaneous production of food, crops, and trees or the intentional designing of land through a system of planting trees, shrubs, crops, or forage in order to improve habitat values, access by humans and wildlife, and woody plant products.

Alternative energy source – Any sources or resources of energy that are renewable through natural processes, can be renewed artifically, or that are regulated as practically inexhaustible. These include solar, wind, geothermal, biomass, and wood resources. Also referred to as renewable energy.

Alternative fuel – Transportation fuels other than gasoline or diesel. Includes natural gas, methanol, and ethanol.

Alternative technology – A technology option that is different than the commonly accepted technology for a specific application (e.g. hybrid car).

Ancillary space – Adequate, safe, and convenient storage that supplements laboratory-classroom space.

Anthropometrics – The study of human body size and motion.

Application – Putting general knowledge and skills to specific use.

Appropriate technology – Part of an international movement to introduce technology that considers in great detail the user and the region/location of the application.

Arrhythmia – An irregular heart rhythm.

Articulate – A planned sequence of curriculum and course offerings from Grades K-12.

Articulation/Articulated – A planned sequence of curricula and course offerings from Grades K-12. The planned sequence may involve looking at course offerings across grade levels (vertical articulation) or the curriculum at a single grade level (horizontal articulation).

Artifact – A human-made object.

Artificial ecosystem – Human-made environment or system that functions as a replication of or to produce the equivalent of the natural environment.

Assessment – 1. An evaluation technique for technology that requires analyzing benefits and risks, understanding the trade-offs, and then determining the best action to take in order to ensure that the desired positive outcomes outweigh the negative consequences. 2. An exercise, such as an activity, portfolio, written test, or experiment that seeks to measure a student's skills or knowledge in a subject area. Information may be collected about teacher and student performance, student behavior, and classroom atmosphere.

Assessment principles – The basic truths, laws, or assumptions held in the use of assessment. The assessment principles that are in current use should enhance student learning, provide coherency of programs and courses, identify expectations, ensure developmental appropriateness, and be barrier-free.

Attributes of Design – Design characteristics that specify that design be purposeful, iterative, creative, and involve many possible solutions.

Authentic assessment – An assessment method that directly examines student performance on tasks that are directly related to what is considered worthy and necessary for developing technological literacy. Traditional assessment, by contrast, relies on indirect or stand-in tasks or questions that are more efficient and simplistic than they are helpful

in determining what students actually know and can do.

Automatic Vehicle Identification (AVI) technology – Technology that is used to collect real-time traffic information.

Barrier-free – Safely accessible for all students, regardless of and with consideration given to student interests, cultures, abilities, socio-economic backgrounds, and special needs.

Basic human needs – Basic needs for survival that include housing, food, sanitation, clean water, and protection from the environment (clothing).

Benchmark – 1. A written statement that describes specific developmental components by various grade levels (K-2, 3-5, 6-8, and 9-12) that students should know or be able to do in order to achieve a standard. 2. A criteria by which something can be measured or judged.

Benefit – A positive outcome for the application of a technological device or process; during an application not all people benefit, and some can benefit at different times.

Best practices – What works and does not work in the laboratory-classroom.

Biodegradable – The ability of a substance to be broken down physically and/or chemically by natural biological processes, such as by being digested by bacteria or fungi.

Bioengineering – Engineering applied to biological and medical systems, such as biomechanics, biomaterials, and biosensors. Bioengineering also includes biomedical engineering as in the development of aids or replacements for defective or missing body organs.

Biological processes – The processes characteristic of, or resulting from, the activities of living organisms.

Biotechnology – Any technique that uses living organisms, or parts of organisms, to make or modify products, improve plants or animals, or to develop microorganisms for specific uses.

Brainstorming – A method of shared problem solving in which all members of a group, spontaneously and in an unrestrained discussion, generate ideas.

British Thermal Unit (BTU) – An English standard unit of energy. One BTU is the amount of thermal energy necessary to raise the temperature of one pound of pure liquid water by one degree Fahrenheit at the temperature at which water has its greatest density (39 degrees Fahrenheit). This is equivalent to approximately 1055 joule (or 1055 watt-seconds).

Bronze Age – The stage or level of development of human culture that followed the Stone Age and was characterized by the use of bronze tools and weapons and ended with the advent of the Iron age; about 3000 B.C.E. to 1100 B.C.E.

Build – To make something by joining materials or components together into a composite whole.

By-product – Something produced in the making of something else; a secondary result; a side effect.

CAD (Computer-Aided Design or Drafting) – 1. (Design) The use of a computer to assist in the process of designing a part, circuit, building, etc. 2. (Drafting) The use of a computer to assist in the process of creating, storing, retrieving, modifying, plotting, and communicating a technical drawing.

Capital – One of the basic resources used in a technological system. Capital (money) is the accumulated finances and goods devoted to the production of other goods.

Carrying capacity – The ability of the planet to meet the needs and wants of all humans and their activities in terms of material and energy resources, ecological cycles, water and air, and the ability to absorb or recycle wastes.

Case studies – An historical account of technology application that may serve as a model solution, expose examples of problems and solutions during design or application, or describe negative impacts as the example to be avoided in future applications.

Category – As used in *Standards for Technological Literacy: Content for the Study of Technology* – the large organizers for the study of technology. The categories are: The Nature of Technology, Technology and Society, Design, Abilities for a Technological World, and The Designed World.

Checklist – An evaluative tool, which could be in many forms, from a simple listing to a formal quarterly report of progress.

Chemical technology – Any technological process that modifies, alters, or produces chemical substances, elements, or compounds.

Class size – The number of students designated to participate simultaneously as a group.

Closed-loop system – A system that uses feedback from the output to control the input.

Co-curricular – The part of a student's educational experience that exists in conjunction with the academic setting but also outside of it.

Cognitive – 1. Having a basis in or being reducible to empirical, factual knowledge. 2. A teaching method that recognizes the close relationship between what is known and what is to be learned. The teaching proceeds to build on the student's knowledge base by helping the student associate new material with something that is familiar.

Cognitive knowledge – The level of understanding just beyond comprehension (basic understanding of meaning). This may include the application of rules, methods, concepts, principles, laws, and theories.

Collaboration – A cooperative relationship that enables goals to be accomplished more effectively and comprehensively than by individual efforts.

Combining – The joining of two or more materials by such processes as fastening, coating, and making composites.

Combustion – To reduce waste volume, local governments or private operators can implement a controlled burning process called combustion or incineration.

Communicate – To exchange thoughts and ideas.

Communication – The successful transmission of information through a common system of symbols, signs, behavior, speech, writing, or signals.

Communication system – A system that forms a link between a sender and a receiver, making possible the exchange of information.

Complex system – A system consisting of interconnected or interwoven parts that interact in such a way as to produce a global output that cannot always be predicted.

Component – A part or element of a whole that can be separated from or attached to a system.

Composite – A combination of two or more materials that are bonded together in an effort to provide better properties.

Compost – Substance composed mainly of partly decayed organic material, used to fertilize the soil and increase its humus content. Usually made from plant materials (e.g., grass clippings and leaves), manure, and soil, and can include chemical fertilizers and lime.

Computer – A machine for carrying out calculations and performing specified transformations of information, such as storing, sorting, correlating, retrieving, and processing data.

Concept map – A visual graphic description of how a main concept is linked to secondary and tertiary concepts and beyond to show relationships.

Concurrent engineering – A systematic approach to the integrated, simultaneous design of products and their related processes, including manufacturing and support.

Conditioning processes – Processes (using force, heat, cold, electricity, etc.) in which the internal structure of a material is changed to alter its properties to make it stronger or improve its function or appearance.

Conflict resolution – A wide range of processes that encourage nonviolent dispute resolution.

Consequence – An effect that naturally follows and is caused by a previous action or condition; referred to as an outcome.

Conservation – The preservation and protection of the environment and the wise use of natural resources.

Constituent – A person or entity that patronizes, supports, or offers representation.

Constraint – A limit to the design process. Constraints may be such things as appearance, funding, space, materials, and human capabilities.

Construction – The systematic act or process of building, erecting, or constructing buildings, roads, or other structures.

Context/Contextual – The circumstances in which an event occurs; a setting.

Content Standard – A written statement about what students should know and be able to do.

Control – An arrangement of chemical, electronic, electrical, and mechanical components that commands or directs the management of a system.

Control system – An assemblage of control apparatus coordinated to execute a planned set of actions.

Continuous – Uninterrupted in time, sequence, substance, or extent.

Continuous-improvement model – The process of identifying educational goals; implementing strategies designed to achieve those goals; collecting data; analyzing the data in light of the goals and strategies; making changes; and continuing the cycle.

Control – An arrangement of chemical, electronic, electrical, and mechanical components that commands or directs the management of a system.

Convention – A technique, practice, or procedure that is established by usage and widely accepted.

Copyright – A form of protection for intellectual property that includes forms of expression, such as artwork, books, and music

Core concepts – A set of ideas that make up the basis for the study of technology. The core concepts of technology as identified in STL are systems, resources, requirements, optimization and trade-offs; processes, and controls.

Cost benefit analysis – Does the cost justify the product? A company would add up the benefits of a course of action, and subtract the costs associated with it.

Courses of study – A series of lessons, activities, projects, or lectures that last a specified period of time and are designed around a specified school subject.

CNC (Computer Numerical Control) – Programmable systems that automatically control the manufacturing process.

Creative thinking – The ability or power used to produce original thoughts and ideas based upon reasoning and judgment.

Credentialed teachers – Teachers who are licensed by a state department of education in a particular area of competence in order to be qualified to teach a particular subject or group of subjects.

Criterion – A desired specification (element or feature) or a product or system.

Critical thinking – The ability to acquire information, analyze and evaluate it, and reach a conclusion to answer by using logic and reasoning skills.

Cross-curricular technology program – Everything that affects student attainment of technological literacy, including content, professional development, curricula, instruction, student assessment, and the learning environment, implemented across grade levels and disciplines. The cross-curricular technology program manages the study of technology in technology laboratory-classrooms and other content area classrooms.

Culture – The beliefs, traditions, habits, and values controlling the behavior of the majority of the people in a social-ethnic group. These include the people's way of dealing with their problems or survival and existence as a continuing group.

Cultural context – The culture setting of beliefs, traditions, habits, and values controlling the behavior of the majority of the people in a social-ethnic group. These include people's ease of dealing with their problems of survival and existence as a continuing group.

Cumulative assessment – Assessment that is summative and usually occurs at the end of a unit, topic, project, or problem.

Curriculum – The subject matter that teachers and students cover in their studies. It describes and specifies the methods, structure, organization, balance, and presentation of the content.

Curriculum development – The process of planned development of curriculum pedagogy, instruction, and presentation modes.

Custom production – A type of production in which products are designed and built to meet the specific needs and wants of an individual.

Cybernetics – Study of automatic control systems: the science or study of communication in organisms, organic processes, and mechanical or electronic systems.

Cybernetics – Study of automatic control systems: the science or study of communication in organisms, organic processes, and mechanical or electronic systems.

Data – Raw facts or figures that can be used to draw a conclusion.

Data processing system – A system of computer hardware and software to carry out a specified computational task.

Decision making – The act of examining several possible behaviors and selecting from them the one most likely to accomplish the individual's or group's intention. Cognitive processes such as reasoning, planning, and judgment are involved.

Decode – To convert a coded message into understandable form using ordinary language.

Delta T – The differential in temperature. For example, if it is -20 degrees Farenheit outside and it is 70 degrees Farenheit inside, the delta T is 90 degrees Farenheit.

Design – An iterative decision-making process that produces plans by which resources are converted into products or systems that meet human needs and wants or solve problems.

Design brief – A written brief that identifies a problem to be solved, its criteria, and its constraints. The design brief is used to encourage thinking of all aspects of a problem before attempting a solution.

Design parameters – Criteria or constraints to the design of a technological device or process based on the factors such as economics, material properties, users, safety issues, and others.

Design principle – Design rules regarding rhythm, balance, proportion, variety, emphasis, and harmony, used to evaluate existing designs and guide the design process.

Design process – A systematic problem-solving strategy, with criteria and constraints, used to develop many possible solutions to solve a problem or satisfy human needs and wants and to winnow (narrow) down the possible solutions to one final choice.

Design proposal – A written plan of action for a solution to a proposed problem.

Develop – To change the form of something through a succession of states or stages, each of which is preparatory to the next. The successive changes are undertaken to improve the quality of or refine the resulting object or software.

Developed nations – Nations that have a higher standard of living or quality of life; usually indicates more technological development.

Developing nations – Nations that are attempting to increase their standard of living or quality of life, usually through the transfer of technology from developed nations.

Developmentally appropriate – Educational programs and methods that are intended to match the needs of students in the areas of cognition, physical activity, emotional growth, and social adjustment.

Diagnose – To determine, by analysis, the cause of a problem or the nature of something.

Diastolic – The number that represents blood pressure when a person's heart is resting between beats.

Discipline – A formal branch of knowledge or teaching (e.g., biology, geography, and engineering) that is systematically investigated, documented, and taught.

Discovery – An insight into the existence of something previously unknown. The act of finding out something new.

Doubling time – A mathematical model to determine how quickly a phenomena that grows at an exponential rate (such as population) will double in size; a rule of thumb is 70/rate (as a whole number)

Drawing – A work produced by representing an object or outlining a figure, plan, or sketch by means of lines. A drawing is used to communicate ideas and provide direction for the production of a design.

Durable goods – Items that can be used for many years.

Dynamic – Ever-changing and evolving.

Economy – The system or range of economic activity, such as production, distribution, and consumption in a country, region, or community that manages domestic affairs and resources.

Educational technology – Using multimedia technologies or audiovisual aids as tools to enhance the teaching and learning process.

Educators – Those professionals involved in the teaching and learning process, including teachers and administrators.

Effective – Produces the desired results with efficiency.

Efficient – Operating or performing in an effective and competent manner, with a minimum of wasted time, energy, or waste products.

Emergent – Occurring as a consequence.

Encode – To change a message into symbols or a form that can be transmitted by a communication system.

Energy – The ability to do work. Energy is one of the basic resources used by a technological system.

Engineer – A person who is trained in and uses technological and scientific knowledge to solve practical problems.

Engineering – The profession of or work performed by an engineer. Engineering involves the knowledge of the mathematical and natural sciences (biological and physical) gained by study, experience, and practice that are applied with judgment and creativity to develop ways to utilize the materials and forces of nature for the benefit of mankind.

Engineering design – The systematic and creative application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.

Engineering ethics – 1. The study of moral issues and decisions confronting individuals and organizations involved in engineering. 2. The study of related questions about moral conduct, character, ideals, and relationships of people and organizations involved in technological development.

Environment – The circumstances or conditions that surround one; surroundings.

Ergonomics – The study of workplace equipment design or how to arrange and design devices, machines, or workspace so that people and things interact safely and most efficiently. Also called human factors analysis or human factors engineering.

Ergonomics – The development of technological devices or processes that match the human body, thus designed for safer applications and less chance of injury.

Ethical – Conforming to an established set of principles or accepted professional standards of conduct.

Evaluation – 1. The collection and processing of information and data in order to determine how well a design meets the requirements and to provide direction for improvements. 2. A process used to analyze, evaluate, and appraise a student's achievement, growth, and performance through the use of formal and informal tests and techniques.

Experiment – 1. A controlled test or investigation. 2. Trying out a new procedure, idea, or activity.

Explicitly – Clearly stated, leaving no ambiguity, and consequently able to be understood and restated by others.

Exponential growth – Growth that is not linear, rather growth by a percentage rate that causes an ever increasing curve (i.e. logarithmic growth).

External review – Evaluation by a group outside of the academic setting that can provide an impartial review of the program for purposes of accountability and improvement.

Externalities – Hidden costs of using energy resources that are not included in the price of the source, such as: treating black lung disease in miners, government subsidies for nuclear power plant insurance, pollution clean-up and health problems from burning fossil fuels, military spending for securing oil supplies, etc.

Extra-curricular – The part of a student's educational experience that exists outside of the academic setting but complements it.

Fact – A statement or piece of information that is true or a real occurrence.

Familial – Of or common to a family.

Feedback – Using all or a portion of the information from the output of a system to regulate or control the processes or inputs in order to modify the output.

Figure – A written symbol, other than a letter, representing an item or relationship, especially a number, design, or graphic representation.

Finite Element Analysis (FEA) – Finite element analysis software products can solve all types of linear and nonlinear stress, dynamics, composite, and thermal engineering analysis problems.

Flow Chart – Diagram showing a sequence of actions: a diagram that represents the sequence of operations in a process.

Forecast – A statement about future trends, usually as a probability, made by examining and analyzing available information. A forecast is also a prediction about how something will develop, usually as a result of study and analysis of available pertinent data.

Formalized assessment – Assessment that is strictly standardized to allow for accurate comparisons.

Formative assessment – Ongoing assessment in the classroom. It provides information to students and teachers to improve teaching and learning.

Forming – The process that changes the shape and size of a material without cutting it.

Global warming – A possible scenario from the release of greenhouse gases from technological activities that could possibly raise the temperature of the planet, causing worldwide flooding as the ice

caps melt, or possibly trigger the opposite effect that would dramatically alter the planet's ecosystem.

Goals – The expected end results. In standards-based education, this can be specifically applied to learning, instruction, student assessment, professional development, and program enhancement.

GPS (Global Positioning System) – GPS is funded by and controlled by the U.S. Department of Defense (DOD). While there are many thousands of civil users of GPS worldwide, the system was designed for and is operated by the U.S. military. GPS provides specially coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity, and time. Four GPS satellite signals are used to compute positions in three dimensions and the time offset in the receiver clock.

Grade level – A stage in the development of a child's education; an acceptable grouping of different grades in school (e.g., K-2, 3-5, 6-8, and 9-12).

Green Map – The Green Map System is a globally connected, locally adaptable eco-cultural program for community sustainability. Green Maps (both printed and online) utilize Green Map Icons to chart the sites of environmental significance around the world.

Greenhouse gas – Gas released due to technological activity (mostly from the burning of fossil fuels) that causes changes in the atmosphere that affect the planet's ability to regulate temperatures and filter harmful ultraviolet rays from the sun.

Gross National Product – Used with Gross Domestic Product (GNP and GDP) to give an indication of how well a county's economy (and thus standard of living or quality of life) are progressing. Also includes activities that are not economically productive such as police and fire protection, health care costs, military costs, etc.

Group Dynamics – Behavior of individuals within groups: the interpersonal processes, conscious and unconscious, that take place in the course of interactions among a group of people (takes a singular verb).

Group project – Specific organized work or research by two or more individuals who interact with and are influenced by each other.

Guidance system – A system that provides information for guiding the path of a vehicle by means of built-in equipment and control.

Guided discovery – A form of instruction in which learning takes place with a limited amount of teacher direction, and students are required to work out basic principles for themselves.

Guideline – Specific requirement or enabler that identifies what needs to be done in order to meet a standard.

Hands-on – Experiences or activities that involve tacit doing as a means of acquiring, or a complement to acquiring, knowledge and abilities.

Hierarchy of needs – Developed by Abraham Maslow to show levels of human need form basic survival needs all the way up to self-esteem and self-actualization needs, needs that are met in succession based on the development of a region.

Holistic – Emphasis of the whole, the overall, rather than analysis and separation into individual parts.

HOV (High Occupancy Vehicle) lanes – Lanes on a highway built primarily for buses that also promote ride sharing through carpools and vanpools.

Human adaptive systems – Systems that exist within the human-made and natural world, including ideological, sociological, and technological systems.

Human Factors Engineering – The study of the human body, its size and motions, as it is related to the design of a product or a system. (See Ergonomics.)

Human scale – Criteria proposed by some experts, based on critical sizes of human cities and other technological systems, that consider how effectively those systems can function without becoming too bureaucratic (and thus ineffective) due to their large size.

Human wants and needs – "Human wants" refers to something desired or dreamed of, and "human needs" refers to something that is required or a necessity.

Hydroponics – A technique of growing plants without soil, in water or sometimes an inert medium (e.g., sand) containing dissolved nutrients.

Hypertext Markup Language (HTML) – The computer language used to create World Wide Web pages, with hyperlinks and markup for text formatting.

Impact – The effect or influence of one thing on another. Some impacts are anticipated, and others are unanticipated.

Impacts – The results of the design, application, or use of technological devices or processes that can be positive or negative, expected or unexpected, and can show up in different regions or in different times.

Industrial Revolution – A period of inventive activity, beginning around 1750 in Great Britain. During this period, industrial and technological changes resulted in mechanized machinery that replaced much of what was previously manual work. The Industrial Revolution was responsible for many social changes, as well as changes in the way things were manufactured.

Informal observation – An assessment method that requires the teacher to observe students at work and note how they interact, solve problems, and ask questions.

Information – One of the basic resources used by technological systems. Information is data and facts that have been organized and communicated in a coherent and meaningful manner.

Information Age – A period of activity starting in the 1950s and continuing today in which the gathering, manipulation, classification, storage, and retrieval of information is central to the workings of society. Information is presented in various forms to a large population of the world through the use of machines, such as computers, facsimile machines, copiers, and CD-ROMs. The Information Age was enhanced by the development of the Internet; an electronic means to exchange information in short periods of time, often instantaneously.

Information system – A system of elements that receive and transfer information. This system may use different types of carriers, such as satellites, fiber optics, cables, and telephone lines, in which switching and storage devices are often important parts.

Informational Technology – Processes associated with generating, storing, retrieving, transferring, and modifying information and data.

Infrastructure – 1. The basic framework or features of a system or organization. 2. The basic physical systems of a country's or a community's population, including transportation and utilities.

Innovate – To renew, alter, or introduce methods, ideas, procedures, or devices.

Innovation – An improvement of an existing technological product, system, or method of doing something.

Inorganic – Lacking the qualities, structure, and composition of living organisms; inanimate.

Input – Something put into a system, such as resources, in order to achieve a result.

In-service – 1. A full-time employee. 2. Workshops and lectures designed to keep practicing professionals abreast of the latest developments in their field.

Instruction – The actual teaching process that the teacher employs to deliver the content to all students.

Instructional technology – The use of computers, multimedia, and other technological tools to enhance the teaching and learning process. Sometimes referred to as educational technology.

Integrated Product Development (IPD) – A philosophy that meticulously teams functional disciplines to integrate, and simultaneously meshes all prescribed processes to produce an effective and efficient product that satisfies the customer's needs.

Integration – The process of bringing all parts together into a whole.

Intellectual property – Property based on the creative mind (intangible) that may include ideas or concepts, art or music, product names or logos, or product recipes or production processes. This type of property can be protected by trade secrets, trademarks, copyrights, or patents.

Intelligence – The capacity to acquire knowledge and the skilled use of reason; the ability to comprehend.

Intelligent transportation system – Proposed evolution of the entire transportation system involving the use of information technologies and advances in electronics in order to revolutionize all aspects of the transportation network. These technologies include the use of the latest computers, electronics, communications, and safety systems to provide traffic control, freeway and incident management, and emergency response.

Interdisciplinary instruction – An educational approach where the students study a topic and its related issues in the context of various academic areas or disciplines.

Intermediate technology – Coined by E. F. Schumacher, this type of technology is a solution for technology transfer that uses less sophisticated technology than in developed nations, but more complex than that used in underdeveloped countries.

Intermodal Transportation (Intermodalism) – Using more than one form of transportation to move goods.

Internet – The worldwide network of computer links, begun in the 1970s, which today allows computer users to connect with other computer users in nearly every country, and speaking many languages.

Invention – A new product, system, or process that has never existed before, created by study and experimentation.

Irradiation – 1. Exposure to radiation. 2. The application of radiation (as X rays or gamma rays) for theraputic purposes or for sterilization (as of food); also: partial or complete sterilization by irradiation.

Irrigation system – A system that uses ditches, pipes, or streams to distribute water artificially.

Iterative – Describing a procedure or process that repeatedly executes a series of operations until some condition is satisfied. An iterative procedure may be implemented by a loop in a routine.

Just-in-Time (JIT) manufacturing – A systems approach to developing and operating a manufacturing system in which manufacturing operation component parts arrive just in time to be picked up by a worker and used.

Kinetic energy – The energy possessed by a body as a result of its motion.

KEVLAR® – A material that is five times stronger than steel on an equal weight basis, yet, at the same time, is lightweight, flexible, and comfortable.

Knowledge – 1. The body of truth, information, and principles acquired by mankind. 2. Interpreted information that can be used.

Laboratory-classroom – The formal environment in school where the study of technology takes place. At the elementary school, this environment will likely be a regular classroom. At the middle and high school levels, a separate laboratory, with areas for hands-on activities as well as group instruction, could constitute the environment.

Large-scale assessment – An assessment tool or method that involves a large number of students, such as across a state/province/region or nation.

Leadership – Guidance, direction, and support.

Learning environment – Formal or informal location where learning takes place that consists of space, cquipment, resources (including supplies and materials), and safety and health requirements.

Literacy – Basic knowledge and abilities required to function adequately in one's immediate environment.

Local – 1. The individual school. 2. The environment defined by the administrative duties of a legally administered public agency within a state or province.

Logo – A symbol of a product, line of products, or a company used to identify the company and allow it to be recognizable for the purposes of marketing (e.g. the swoosh used by Nike).

Long-range planning – Planning that spans weeks, months, or even years and may not commence until sometime in the future.

Machine – A device with fixed and moving parts that modifies mechanical energy in order to do work.

Macrosystem – A comprehensive, all-inclusive system.

Maintenance – The work needed to keep something in proper condition; upkeep.

Manageable class size – The number of students that (a) designated teacher(s) is/are able to most effectively and safely guide, direct, and instruct.

Manageable teacher schedule – A daily, weekly, monthly, semester, and term itinerary that allows teachers to accomplish goals for teaching and learning.

Management – The act of controlling production processes and ensuring that they operate efficiently and effectively; also used to direct the design, development, production, and marketing of a product or system.

Manufacturing – The process of making a raw material into a finished product; especially in large quantities.

Manufacturing system – A system or group of systems used in the manufacturing process to make products for an end user.

Market – 1. A subset of the population considered to be interested in the buying of goods or services. 2. A place where goods are offered for sale.

Marketing – The act or process of offering goods or services for sale.

Mass production – The manufacture of goods in large quantities by means of machines, standardized design and parts, and, often, assembly lines.

Material – The tangible substance (chemical, biological, or mixed) that goes into the makeup of a physical object. One of the basic resources used in a technological system.

Mathematics – The science of patterns and order and the study of measurement, properties, and the relationships of quantities; using numbers and symbols.

Measurement – The process of using dimensions, quantity, or capacity by comparison with a standard in order to mark off, apportion, lay out, or establish dimensions.

Medical Technology – Of or relating to the study of medicine through the use of and advances of technology, such as medical instruments and apparatus, imaging systems in medicine, and mammography. Related terms: bio-medical engineering and medical innovations.

Medicine – The science of diagnosing, treating, or preventing disease and other damage to the body or mind.

Mentor – A mentor possesses knowledge and experience and shares pertinent information, advice, and support while serving as a role model.

Mesolithic – The middle period of the Stone Age, between the Paleolithic and Neolithic.

Message –1. The information sent by one source to another, usually short and transmitted by words, signals, or other means. 2. An arbitrary amount of information whose beginning and end are defined or implied.

Meta-cognition – Learners reflecting upon their own process of thinking and learning.

Micro-processing system – A computer made up of integrated circuits that is capable of high speed electronic operations.

Middle Ages – The period in European history between antiquity and the Renaissance, often dated from A.D. 476 to 1453.

Mission – Organized goals and strategies for realizing goals that could be articulated in a mission statement.

Mixed-natural materials – Natural materials modified to improve their properties. Mixed-natural materials may be leather, plywood, or paper, for example.

Mobility – The quality or state of being mobile; capable of moving or being moved.

Model – A visual, mathematical, or three-dimensional representation in detail of an object or design, often smaller than the original. A model is often used to test ideas, make changes to a design, and to learn more about what would happen to a similar, real object.

Modeling – The act of creating a model.

Modular environments – Areas that, by design, allow for flexibility, as they can be arranged in a variety of ways to suit the purpose of the specific activity or lesson.

Module – A self-contained unit.

Moore's Law – Each new memory chip contained roughly twice as much capacity as its predecessor, and each chip was released within 18-24 months of the previous chip. This is the basis for the theory that technology doubles every 1 1/2 years.

Multimeter – An instrument that reads and measures the values of several different electrical parameters such as current, voltage, and resistance.

Multimedia – Information that is mixed and transmitted from a number of formats (e.g., video, audio, and data).

Municipal Solid Waste – More commonly known as trash or garbage—consists of everyday items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries.

Napster – Was a protocol for sharing files between users. With Napster, the files stayed on the client machine, never passing through the server. The server provided the ability to search for particular files and initiate a direct transfer between the clients.

Natural material – Material found in nature, such as wood, stone, gases, and clay.

Neolithic – The latest period of the Stone Age, between about 8000 BC and 5000 BC, characterized by the development of settled agriculture and the use of polished stone tools and weapons.

Network – An interconnected group or system. The Internet is a network of computers.

Noise – An outside signal that interrupts, interferes, or reduces the clarity of a transmission.

Non-biodegradable – The inability of a substance to be broken down (decomposed) and therefore retaining its form for an extended period of time.

Non-durable goods – Items that do not last and are constantly consumed, such as paper products.

Noninvasive – A test or procedure that can be conducted without any tools entering the patient's body.

Nonlinear – Not in a straight line.

Nonrenewable – An object, thing, or resource that cannot be replaced.

Nuclear power – Power, the source of which is nuclear fission or fusion.

Nuclear Stress test – In addition to the procedures that are performed as part of a standard stress test, a patient scheduled for a nuclear stress test is injected with a very small, harmless amount of a radioactive (radionuclide) substance, such as thallium. Once in the patient's body, this substance emits rays that can be picked up by a special (gamma) camera. The rays allow the camera to produce clear pictures of heart tissue on a video monitor. These pictures show contrasts between light and dark spots, which can indicate areas of damage or reduced blood flow that are present before, during, and after exertion.

Objective – A specific item or procedure that meets a designated goal.

Obsolescence – Loss in the usefulness of a product or system because of the development of an improved or superior way of achieving the same goal.

Open-loop system – A control system that has no means for comparing the output with input for control purposes. Control of open-loop systems often requires human intervention.

Optimization – An act, process, or methodology used to make a design or system as effective or functional as possible within the given criteria and constraints.

Optimization – A technological design process that strives to meet all the design criteria for a product with the least amount of costs (economic, environmental, safety).

Orthographic projection – That projection which is made by drawing lines, from every point to be projected, perpendicular to the plane of projection. Such a projection of the sphere represents its circles as seen in perspective by an eye supposed to be placed at an infinite distance, the plane of projection passing through the center of the sphere perpendicularly to the line of sight.

Output – The results of the operation of any system.

Paleolithic – The early part of the Stone Age, when early human beings made chipped-stone tools—from 750,000 to 15,000 years ago.

Paper-and-pencil test – An assessment method that involves the use of questions that are typically answered in a timed setting using paper and pencil.

Patent – A document issued from the government granting the exclusive right to produce or sell an invention for a certain period of time.

Patent – Protection for the intellectual property of inventions and innovations, allowing the creators to benefit from their efforts and allow the continuation of the creative process.

Pedagogical – Of or relating to the deliberately applied science/art, methodologies, and strategies of teaching.

Peer assessment – An assessment method that involves the use of feedback from one student to another student, both students being of similar standing (grade level).

Peer evaluation – A way for a group to evaluate its members according to their participation on a project.

Performance – A demonstration of student-applied knowledge and abilities, usually by presenting students with a task or project and then observing, interviewing, and evaluating their solutions and products to assess what they actually know and can do.

Performance-based method – A lesson or an activity that is designed to include performances that involve students in the application of their knowledge.

Perspective – An individual point of view based on experience.

Pharmaceuticals – A natural or artificial substance that is given to treat, prevent, or diagnose a disease or to lessen pain.

Photochemistry – Study of the chemical effects of light; a branch of chemistry that studies the effect of radiation, especially of visible and ultraviolet light, on chemical reactions and of the emission of radiation by chemical reactions.

Photovoltaic – Capable of producing a voltage when exposed to radiant energy, especially light.

Pictogram – Instructions in "cartoon" format so that language is not a problem for people.

Plan – A set of steps, procedures, or programs, worked out beforehand in order to accomplish an objective or goal.

Political – Of or relating to the structure and affairs of a government, state, or locality and its related politics.

Pollution – The changing of a natural environment, either by natural or artificial means, so that the environment becomes harmful or unfit for living things; especially applicable to the contamination of soil, water, or the atmosphere by the discharge of harmful substances.

Polymer – Any of numerous natural and synthetic compounds of usually high molecular weight consisting of up to millions of repeated linked units, each a relatively light and simple molecule.

Poly Vinyl Chloride (PVC) – A polymer (plastic) typically used in household plumbing and other applications.

Portfolio – A systematic and organized collection of a student's work that includes results of research, successful and less successful ideas, notes of procedures, and data collected.

Potential energy – The energy of a particle, body, or system that is determined by its position or structure.

Power – 1. The amount of work done in a given period of time. 2. The source of energy or motive force by which a physical system or machine is operated.

Power system – A technological system that transforms energy resources to power.

Practical context – The everyday environment in which an event takes place.

Practices – The established applications of knowledge.

Pre-service – Undergraduate coursework taken by those intending to teach.

Principle – A basic truth, law, or assumption that is widely accepted and followed as a general rule or standard.

Problem solving – The process of understanding a problem, devising a plan, carrying out the plan, and evaluating the plan in order to solve a problem or meet a need or want.

Procedural knowledge – Knowing how to do something.

Process – 1. Human activities used to create, invent, design, transform, produce, control, maintain, and use products or systems; 2. A systematic sequence of actions that combines resources to produce an output.

Produce – To create, develop, manufacture, or construct a human-made product.

Product – A tangible artifact produced by means of either human or mechanical work, or by biological or chemical processes.

Product liability – The imposing of liability to a product supplier of tangible or intangible goods to protect against, or compensate for, injury or death from use of those products.

Product lifecycle – Stages a product goes through, from concept and use to eventual withdrawal from the marketplace. Product life cycle stages include research and development, introduction, market development, exploitation, maturation, saturation, and finally decline.

Product safety – The responsibility of technological designers to develop products that are safe to operate, use repetitively, or dispose of when the useful life of the product is over.

Production system – A technological system that involves producing products and systems by manufacturing (on the assembly line) and construction (on the job).

Professional – Of or relating to practicing one's occupation with skill, knowledge, dedication, and with a conscious accountability for one's actions.

Professional development – A continuous process of lifelong learning and growth that begins early in life, continues through the undergraduate, pre-service experience, and extends through the in-service years.

Professional Engineer (PE) – Only a licensed engineer may prepare, sign and seal, and submit engineering plans and drawings to a public authority for approval, or seal engineering work for public and private clients.

Program – Everything that affects student learning, including content, professional development, curricula, instruction, student assessment, and the learning environment, implemented across grade levels.

Project – A teaching or assessment method used to enable students to apply their knowledge and abilities. These may take many forms and are limited by time, resources, and imagination.

Propulsion system – A system that provides the energy source, conversion, and transmission of power to move a vehicle.

Prototype – A full-scale working model used to test a design concept by making actual observations and necessary adjustments.

Prototyping – The act of creating a prototype, such as an original type, form, or instance, that serves as a working model on which later stages are based or judged.

Psychomotor – 1. Physical behavior that has a basis in mental processes. 2. A teaching method that involves both mental processes and physical movement.

Qualified teacher – An individual possessing the necessary knowledge and skills to effectively teach specified subject matter to students in specified grade levels.

Quality control – A system by which a desired standard of quality in a product or process is maintained. Quality control usually requires feeding back information about measured defects to further improvements of the process.

Quality of life – An indication of how satisfied people of a region or country live, work, and have access to leisure based on many (and varied) factors such as the satisfaction of their hierarchy of needs, access to work and education, health issues, etc.

Questioning – A technique of informal assessment and instruction, wherein the teacher guides the direction, understanding, and application of the information being taught through the use of questions, and also attempts to identify student misconceptions, and uses that information to adjust instruction.

Rate of adoption – Indicates how fast a new or improved technology is accepted or rejected by people, including a study of the factors that affected its adoption.

Rating factor – Criteria used by designers to evaluate the effectiveness of a technological product or process by comparing like products or processes and optimizing the design based on which has the highest overall indication using all rating factors.

Receiver – The part of a communication system that picks up or accepts a signal or message from a channel and converts it to perceptible forms.

Recycle – To reclaim or reuse old materials in order to make new products.

Reliability – Capable of being relied on; dependable; may be repeated with consistent results.

Renaissance – The transitional movement in Europe between medieval and modern times beginning in the 14th century in Italy, lasting into the 17th century, and marked by a humanistic revival of classical influence expressed in a flowering of the arts and literature and the beginnings of modern science.

Renewable – Designation of a commodity or resource, such as solar energy or firewood, that is inexhaustible or capable of being replaced by natural ecological cycles or sound management practices.

Request for Proposal (RFP) – An RFP in its most formal sense is a specification of requirements that is sent out to suppliers who reply with proposals. Although common with large companies, the idea can be usefully applied at varying levels of sophistication to small and medium organizations as well. Used properly, it is a tool that supports and protects the buyer.

Requirements – The parameters placed on the development of a product or system. The requirements include the safety needs, the physical laws that will limit the development of an idea, the available resources, the cultural norms, and the use of criteria and constraints.

Research – Systematic, scientific, documented study.

Research and Development (R&D) – The practical application of scientific and engineering knowledge for discovering new knowledge about products, processes, and services, and then applying that knowledge to create new and improved products, processes, and services that fill market needs.

Resources – The things needed to get a job done. In a technological system, the basic technological resources are: energy, capital, information, machines and tools, materials, people, and time.

Risk – The chance or probability of loss, harm, failure, or danger.

Risks – Used by technological designers to predict any types of loss (negative impact) to those who will use the product or will be impacted by its use; based of the costs (not just economic) and the probability of the occurrence of a negative impact.

Risk/benefit analysis – Does the risk of building the product outweigh the negative societal impact? Risk = probability of event x cost of event.

Rote memorization response – A response that is generated by memory alone, without understanding or thought.

Rubric – An assessment or evaluative device based on the identified criteria taken from the content standards. Points or works are assigned to each phase or level of accomplishment. This method gives feedback to the students about their work in key categories, and it can be used to communicate student performance to parents and administrators.

R-Value – The resistance level of a material. This number can be associated with building materials lists or can be derived from an experiment that can be done to determine the R-value of a material.

Sanitation – The design and practice of methods for solving basic public health problems, such as drainage, water and sewage treatment, and waste removal.

Scale – A proportion between two sets of dimensions used in developing accurate, larger or smaller prototypes, or models of design ideas.

Schematic – A drawing or diagram of a chemical, electrical, or mechanical system.

School district – The administrative boundaries of a legally admimistered public agency within a locality or state/province/region.

Science – The study of the natural world through observation, identification, description, experimental investigation, and theoretical explanations.

Scientific inquiry – The use of questioning and close examination using the methodology of science.

Self-assessment/Self-reflection – An assessment method that encourages individuals to evaluate themselves, for example, in terms of their learning or teaching.

Sender – A person or equipment that causes a message to be transmitted.

Separating – The process of using machines or tools to divide materials.

Service – 1. The installation, maintenance, or repairs provided or completed by a dealer, manufacturer, owner, or contractor. 2. The performance of labor for the benefit of another.

Short-range planning – Planning for the immediate future and for a relatively short period of time; for example, the next day, week, or the rest of the grading period.

Side effect – A peripheral or secondary effect, especially an undesirable secondary effect. Some side effects become the central basis for new developments.

Simulation – 1. A method of instruction that attempts to re-create real-life experiences. 2. A modeling tool that allows designers to evaluate a system or process by mimicking the process (using software or other tools) and changing parameters and predicting what might happen or make refinements.

Sketch – A rough drawing representing the main features of an object or scene and often made as a preliminary study.

Skill – An ability that has been acquired by training or experience.

Society – A community, nation, or broad grouping of people having common traditions, institutions, and collective activities and interests.

Social – Relating to human society and how it is organized.

Soft technology – A technology that is generally of less complexity, requires less expertise to use or manage, has fewer impacts on the people who use it or the environment, and is readily available to many people.

Solution – A method or process for solving a problem.

Source Reduction – Often called waste prevention, it means consuming and throwing away less.

Space – 1. The continuous expanse beyond the earth's atmosphere, as in space exploration. 2. The area alloted for a specific purpose, as in classroom space.

Stakeholder – An individual or entity who has an interest in the success of a specific venture or program. Stakeholders may include teachers, administrators, school leaders, professional development providers, business and industryu leaders, engineers, scientists, technologists, and others.

Standard – A written statement or statements about what is valued that can be used for making a judgment of quality.

Standard of living – A measure of how "well off" a region or country is, based on their material and social needs; often simplistically only tied to GNP (see above), which typically only measures economic standards.

Standardization – The act of checking or adjusting by comparison with a standard.

Stone Age – The first known period of prehistoric human culture, characterized by the use of stone tools.

Structural system – A system comprised of the framework or basic structure of a vehicle.

Structure – Something that has been constructed or built of many parts and held or put together in a particular way.

Strategic planning – A disciplined effort to produce fundamental decisions and actions that shape and guide what an organization is, what it does, and why it does it, with a focus on the future.

Student assessment – A systematic, multi-step process of collecting evidence on student learning, understanding, and abilities and using that information to inform instruction and provide feedback to the learner, therby enhancing student learning.

Student interview – An assessment method that includes a planned sequence of questions, similar to a job interview. Students are not given information, as the objective is to collect data on student knowledge and abilities at a certain point in time. In contrast, a student conference suggests a discussion, with both student and teacher idea-sharing taking place.

Student presentation/demonstration – An assessment method that involves student explanation and communication of their understanding of key ideas, concepts, and principles and abilities of processes, techniques, and skills.

Study of technology – Any formal or informal education about human innovation, change, or modification of the natural environment.

Subsystem – A division of a system that, in itself, has the characteristics of a system.

Summative assessment – Cumulative assessment that usually occurs at the end of a unit, topic, project, or problem. It identifies what students have learned and judges student performance against previously identified standards. Summative assessment is most often thought of as final exams, but may also be a portfolio of student work.

Support system – 1. A network of personnel or professionals that provides life, legal, operational, maintenance, and economic support for the safe and efficient operation of a system, such as a transportation system. 2. The technical system that supports the operation of a system, as in a lide support system on board the Shuttle.

Suspension system – A system of springs and other devices that insulates the passenger compartment of a vehicle from shocks transmitted by the wheels and axles.

Sustainable – 1. Of or relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged. 2. Relating to a human activity that can be sustained over the long term, without adversely affecting the environmental conditions (soil conditions, water quality, climate) necessary to support those same activities in the future.

Sustainable development – 1. Improving the quality of human life while living within the carrying capacity of supporting ecosystems. 2. Technological or economic development that does not use up resources (materials and energy) faster than they can be generated, and affects the environment and other natural systems at a rate that does not cause long-term harm.

Symbol – An arbitrary or conventional sign that is used to represent operations, quantities, elements, relations, or qualities or to provide directions or alert one to safety.

Synthetic material – Material that is not found in nature, such as glass, concrete, and plastic.

System – A group of interacting, interrelated, or interdependent elements or parts that function together as a whole to accompish a goal.

Systems-oriented – Looking at a problem in its entirety, looking at the whole as distinct from each of its parts or components, taking into account all of the variables and relating social and technological characteristics.

Systolic – The number that represents blood pressure while a person's heart is beating.

Tactile – Stimulation through the sense of touch.

Teacher candidate – An individual preparing to teach.

Teaching – The concious effort to bring about learning in a manner that is clearly understood by the learner and likely to be successful.

Teamwork – A cooperative effort by the members of a group or team to achieve a common goal.

Technological competency – What some people need to be successful in a technical career.

Technological design – See Engineering design.

Technological issues – Issues that arise from the applications of technology into human social and economic systems that result in a variety of benefits, costs, risks, and limitations.

Technological literacy – The ability to use, manage, understand, and assess technology.

Technological literacy standard – A written statement that specifies the knowledge (what students should know) and process (what students should be able to do) students should possess in order to be technologically literate.

Technology – 1. Human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend capabilities. 2. The innovation, change, or modification of the natural environment to satisfy perceived human needs and wants.

Technology assessment – Evaluating the potential impacts of applying a technology, positive or negative, expected or unexpected, prior to its implementation to reduce possible technological issues.

Technology education – A study of technology, which provides an opportunity for students to learn about the processes and knowledge related to technology that are needed to solve problems and extend human capabilities.

Technology program – Everything that affects student attainment of technological literacy, including content, professional development, curricula, instruction, student assessment, and the learning environment, implemented across grade levels as a core subject of inherent value.

Technology transfer – Transferring technological devices or processes to another region or country, and evaluating the factors that affect its acceptance, both social and technological.

Technological studies – See technology education.

Technological transfer – The process by which products, systems, knowledge, or skills, developed under federal research and development funding, are translated into commercial products to fulfill public and private needs.

Telemedicine – The investigation, monitoring, and management of patients and the education of patients and staff using systems that allow ready access to expert advice and patient information, no matter where the patient or the relevant information is located. The three main dimensions of telemedicine are health service, telecommunications, and medical computer technology.

Test – 1. A method for collecting data. 2. A procedure for critical evaluation.

Thematic unit – Set of lesson presentations that organize classroom instruction around certain texts, activities, and learning episodes related to a topic(s). A thematic unit might integrate several content areas.

Thumbnail sketching – Small drawings/sketches used during brainstorming. These are not to scale and usually small, hence the name thumbnail.

Tolerances – Allowed amount of variation from the standard or from exact conformity to the specified dimensions, weight, etc., as in various mechanical operations.

Tool – A device that is used by humans to complete a task.

Trade-off – 1. An exchange of one thing in return for another; especially relinquishment of one benefit or advantage for another regarded as more desirable. 2. Technological design parameters that have more than one impact that often contradict each other, causing the designer to make decisions based on best-case scenarios.

Trademark – A protection of intellectual property that covers any words, names, symbols, or devices (such as packages) that identify the producer, often

protected for marketing purposes, which include product names, logos, and packaging.

Trade secret – A protection of intellectual property that covers a secret process or product, which includes such things as the formula for Coca-Cola™ or a cookie recipe.

Transistor – A solid-state electronic device; a small low-powered solid-state electronic device consisting of a semiconductor and at least three electrodes, used as an amplifier and rectifier and frequently incorporated into integrated circuit chips.

Transmit – To send or convey a coded or non-coded message from a source to a destination.

Transportation system – The process by which passengers or goods are moved or delivered from one place to another.

Trend – 1. A tendency. 2. A general direction.

Trend analysis – A comparative study of the component parts of a product or system and the tendency of a product or system to develop in a general direction over time.

Trial and error – A method of solving problems in which many solutions are tried until errors are reduced or minimized.

Troubleshoot – To locate and find the cause of problems related to technological products or systems.

U-Factor – The combined thermal conductivity of materials (1/R Value).

Ultrasound – The ultrasound machine sends out high-frequency sound waves that bounce off body structures to create a picture.

Unit – An organized series of learning activities, lectures, projects, and other teaching strategies that focuses on a specific topic related to the curriculum as a whole.

Use – The act or practice of employing something to put it into action or service.

Validity – Having or containing premises from which the conclusion may logically be derived, correctly inferred, or deduced.

Vignette – In *Standards for Technological Literacy: Content for the Study of Technology*, a brief description or verbal snapshot of how a standard or group of standards may be implemented in the laboratory-classroom.

Virtual – Simulation of the real thing in such a way that it presents reality in essence, or in effect, though not in actual fact.

Vision – A contemplative image of future promise and possibility articulated with the intention to inspire others.

Vocational education – Training within an educational institution that is intended to prepare an individual for a particular career or job.

Vulcanize – To treat gum (crude rubber) with sulfur under heat to increase its strength and elasticity; to thermoset its structure so that it can no longer be melted.

Waste – Refuse or by-products that are perceived as useless, and must be consumed, left over, or thrown away.

Weighting factors – A number assigned to a rating factor during product optimization that identifies how important the rating factor is compared to the rest of the factors, and allows the designer to mathematically select the best (perceived) design.

Work – The transfer of energy from one physical system to another, expressed as the product of a force and the distance through which it moves a body in the direction of that force.

Workstation – A student work area, including all the components that occupy the space, such as furniture and equipment.

World Wide Web (WWW) – An abstract (imaginary) space of information that includes documents, color images, sound, and video.

Appendix E
Pre/Post Content Knowledge Questions

The following questions are taken from each unit lessons. They represent the knowledge assessment component for each lesson, but may be used as a pre-assessment tool.

Directions
Select the response that best answers the question or statement.

Unit 1: Lesson 1 Introduction to Technological Issues Using an Historical Case Study

_____ 1-1A. The development of a technology is influenced by
A. economics
B. its technical feasibility
C. social factors
D. all of the above

_____ 1-1B. The relationship between technology and social institutions can be described as:
A. technology and social institutions do not effect one another
B. technology developments can affect social institutions
C. social institutions can affect the development of technology
D. both B. and C. above

_____ 1-1C. The effects of a particular technology generally
A. have a major impact on society
B. have minimum impact on society
C. have no impact on society
D. impact society depending on the technology

_____ 1-1D. The historical effects of a technology show that
A. all technologies are accepted by society
B. few technologies are accepted by society
C. society at the time can affect its acceptance
D. society has no affect on its acceptance

_____ 1-1E. Mathematical tools used to organize research information are called
A. tables
B. charts
C. data bases
D. all of the above

Unit 1: Lesson 2 Relating Technological Issues to Other Subject Areas

_____1-1A. The discipline that is closest to the study of technology is
A. social studies
B. science
C. mathematics
D. depends on the technology

_____ 1-2B. The relationship between mathematics and technology can be described as
A. there is no relationship between mathematics and technology
B. mathematical tools are used in the design and application of technology
C. technological devices are used to calculate and store mathematical information
D. both B. and C. above

_____ 1-2C. The relationship between science and technology can be described as
A. science concepts are used to better understand technology
B. technological devices are used to discover scientific principles
C. there is no connection between science and technology
D. both A. and B. above

_____ 1-2D. The relationship between the arts and technology can be described as
A. there is no relationship between the arts and technology
B. both C. and D. below
C. artistic principles can enhance the aesthetics of a technological product
D. technological devices can help create new artistic interpretations

_____ 1-2E. Visual tools used to organize and connect information relationships are called
A. seating charts
B. concept maps
C. branch charts
D. data base lists

Unit 1: Lesson 3 Examining a Technology and its Adoption

_____ 1-3A. In general, the rate of adoption of technology processes and devices occurs
A. at a very slow pace
B. over a gradual period
C. at a rapid pace
D. depending on the technology

_____ 1-3B. The group of people that accept a technology first are called the
A. resisters
B. innovators
C. early majority
D. great majority

_____ 1-3C. Lower level needs, those that are first satisfied, are those of
A. safety and self-esteem
B. social and self esteem
C. survival and safety
D. survival and self-actualization

_____ 1-3D. Mathematical tools that use columns and rows to organize information are called
A. tables
B. graphs
C. coordinates
D. charts

_____ 1-3E. A factor that may affect the rate of technological adoption include is
A. technical feasibility
B. social acceptance
C. scientific sophistication
D. all of the above

Unit 1: Lesson 4 Technology Alternatives: Benefits and Risks

_____ 1-4A. The benefits of a technology
A. effect everyone the same
B. always effect the majority
C. may only benefit a few people
D. always outweigh the risks

_____ 1-4B. The risks of a technology
A. affects everyone the same
B. only affects a minority
C. may affect people at a later date
D. are always outweighed by its benefits

_____ 1-4C. A risk-benefit analysis should consider all of the following except
A. who will be involved
B. when the benefits or risks will occur
C. economic decisions
D. all should be considered in the analysis

_____ 1-4D. A risk-benefits analysis should be conducted
A. immediately after the technology is in place
B. to eliminate all unwanted side effects
C. to minimize potential issues
D. only for dangerous technologies

_____1-4E. Which statement is true for technology alternatives?
A. alternatives should have risk-benefits analysis similar to conventional technologies
B. alternatives have fewer risks than conventional technologies
C. alternatives create more benefits than conventional technologies
D. alternatives are not considered because they are more expensive

Unit 2: Lesson 1 Examining Exponential Growth

_____ 2-1A. Systems that grow and exponential rates include
A. economies
B. population
C. bank accounts
D. all of the above

_____ 2-1B. Which of these statements about linear versus exponential growth is true:
A. linear growth, at the same rate as an exponential system, will be larger in 20 years
B. linear and exponential growth systems of the same rate will be equal in size in 20 years
C. an exponential growth, at the same rate as a linear system will be larger in 20 years
D. the rate does not affect either linear or exponential systems

_____ 2-1C. A technology growth rate of 2% means that the world's technology will double in how many years?
A. 20
B. 35
C. 50
D. 100

_____ 2-1D. The number 1,200,000,000 can be written as scientific notation as
A. 12×10^9
B. 1.2×10^8
C. 1.2×10^9
D 12×10^8

_____ 2-1E. An exponential growth rate can be shown on a graph as a
A. upward curve
B. downward curve
C. straight line
D. V-shaped line

Unit 2: Lesson 2 Evaluating Technology Transfer

_____ 2-2A. In Maslow's hierarchy of needs, the lowest level is
A. social B. physiological
B. self-esteem D. self-actualization

_____ 2-2B. In Maslow's hierarchy of needs, the highest level is
A. social B. physiological
B. self-esteem D. self-actualization

_____ 2-2C. Technology transfer is done for
A. economic needs B. military needs
C. social needs D. all of the above

_____ 2-2D. The best way to define standard of living is by
A. gross national product B. basic human needs
C. salaries of workers D. a variety of measures

_____ 2-2E. Technology transfer is the movement from one region to another of a technological
A. process B. product
C. infrastructure C. all of the above

Unit 2: Lesson 3 Issues From Engineering Design Failures

_____ 2-3A. A level one type of product failure is
A. electrical B. physical
C. process error D. perspective or attitude

_____ 2-3B. A level three type of product failure is
A. electrical B. physical
C. process error D. perspective or attitude

_____ 2-3C. An example of a process error product failure would be
A. inadequate training B. lack of motivation
C. excessive noise or vibration D. impulsive behavior or decision making

_____ 2-3D. Organizations such as the Society of Automotive Engineers (SAE) provide designers with
A. design criteria B. design constraints
C. design standards D. all of the above

_____ 2-3E. Engineering design criteria and constraints are important for how
A. a product is used B. a product is manufactured
C. a product is disposed of D. all of the above

_____ 2-4A. Inexhaustible energy sources means that
A. they will never run out
B. they are available in large quantities
C. they can be regenerated faster than depleted
D. they do not produce exhausts

_____ 2-4B. An example of an exhaustible energy source would be
A. tidal waves
B. uranium
C. geothermal
D. wood

_____ 2-4C. An example of a renewable energy source would be
A. biomass
B. geothermal
C. natural gas
D. wind

_____ 2-4D. Conservation techniques or devices typically
A. cost more than they save
B. are only used on exhaustible resources
C. can delay the depletion of a resource
D. all of the above

_____ 2-4E. Large numbers, used to estimate natural resources or other large quantity, can be written using
A. logarithms
B. base twenty system
C. scientific notation
D. subscripts

Unit 3: Lesson 1 **Design Technology for Quality of Life**

_____ 3-1A. The quality of life for all communities in the United States is
A. of the highest quality for all people
B. varies depending on region
C. is lower than most countries
D. is related to economic activity

_____ 3-1B. In Maslow's hierarchy of needs, the most difficult to measure is
A. self-esteem
B. safety
C. self-actualization
D. physiological

_____ 3-1C. Quality of life is often hard to determine because
A. the definition can vary
B. data is not always available
C. regions have different comparison methods
D. regions are too different to compare

_____ 3-1D. A comprehensive measure of the quality of life includes
A. education levels
B. standards of living
C. poverty levels
D. all of the above

_____ 3-1E. A factor that help determine which technologies are selected in a region/country include
A. personal values
B. consumer acceptance
C. economic competition
D. all factors have some influence

Unit 3: Lesson 2 Criteria for Safe and Ergonomic Design

_____ 3-2A. Upon examining product safety issues, an accident is usually the fault of
A. the designer
B. the operator
C. a combination of A. and B.
D. neither A. or B.

_____ 3-2B. Charts used to show sizes of typical human dimensions are called
A. anthropomorphic
B. medical
C. dimensional
D. agronomical

_____ 3-2C. Safe design includes the careful development for a product's
A. operation
B. manufacture
C. maintenance
D. all of the above

_____ 3-2D. Ergonomic designs concern themselves with how a product
A. is manufactured
B. is maintained
C. interacts with the user
D. all of the above

_____ 3-2E. One example of an ergonomic design flaws results from
A. repetitive use
B. flawed parts
C. inferior quality
D. all of the above apply

Unit 3: Lesson 3 Design Ethics and Product Liability

_____ 3-3A. Engineering designers are regulated by themselves through
A. state law
B. design standards
C. code of ethics
D. all of the above

_____ 3-3B. Professional engineering societies are organized in order to
A. regulate their members
B. protect their members
C. punish offenders
D. all of the above

_____ 3-3C. Product defects include which of the following
A. manufacturing flaws
B. design defects
C. defective warnings or instructions
D. all of the above

_____ 3-3D. Agencies or organizations created to protect the public are characterized as
A. governmental
B. private
C. professional
D. both A. and B.

_____ 3-3E. Legislative acts, such as the Occupational Safety and Health Act, were created to protect
A. the public
B. manufacturing firms
C. government employees
D. designers

Unit 3: Lesson 4 Modeling Monitoring Technology

_____ 3-4A. Environmental impacts from human technology can best be described as
A. much less of an impact than from natural causes
B. much more of an impact than natural causes
C. having an increase impact due to increases of human activity
D. totally responsible for environmental impacts to air, water and soil

_____ 3-4B. Future environmental impacts from technology must consider
A. increases in the use of the technology
B. increases in population
C. a variety of technical studies
D. all of the above

_____ 3-4C. Some environmental conditions, such as water or soil pH, use logarithmic scales, meaning that a change from a ph of 4 to 5 indicates what type of change?
A. an increase of one percent
B. a doubling
C. a change of ten percent
D. a change of 25 percent

_____ 3-4D. Monitoring technologies are generally considered
A. too much of an economic burden
B. based on risks and benefits
C. not worth the improvements they generate
D. too complicated to develop

_____ 3-4E. The implementation of a monitoring technologies typically
A. is helped by regulations
B. involves social issues
C. spreads the cost disproportionably among people
D. all of the above

Unit 4: Lesson 1 Appropriate Technology Design

_____ 4-1A. Appropriate technology may be defined as
A. the same as alternative technology
B. the most sophisticated technology
C. designed for the people who will use it
D. all of the above

_____ 4-1B. Criteria for appropriate technology must include
A. needs of the user.
B. inexpensive
C. simplicity
D. all of the above

_____ 4-1C. Constraints of appropriate technology design include
A. available infrastructure
B. maintainability
C. social acceptability
D. all of the above

_____ 4-1D. Appropriate technology is generally designed for
A. developing regions B. poor regions
C. regions with low-level technology D. all regions

_____ 4-1E. When brainstorming ideas for development, the design group should
A. dismiss silly ideas
B. document all ideas
C. document only those ideas that seem good
D. discuss each idea

Unit 4: Lesson 2 Model City Design Based on Recycling & Green Products

_____ 4-2A. According to many experts, the size of the optimal city or community is approximately how many people?
A. less than 10,000 B. 10,000 -50,000
C. 50,000 – 1,000,000 D. at least 1,000,000

_____ 4-2B. A product labeled green, indicates that the product
A. will cost a lot of money B. is made of all natural materials
C. is used in landscaping D. is environmentally safe

_____ 4-2C. A process or device called an "alternative technology", usually indicates
A. a technology used less B. the best technology available
C. the safest technology available D. the only technology available

_____ 4-2D. Recycling products can aid in the following:
A. the use of less materials B. the use of less energy
C. the need for less landfills D. all of the above

_____ 4-2E. Using a ratio of 48:1 to make a model, a building that is 36 feet wide would be how large in the scaled model?
A. 1.33 inches B. 12 inches
C. 9 inches D. 16 inches

Unit 4: Lesson 3 Debating Current Technologies and Their Issues

_____ 4-3A. Debates on the merits of a technology should use what type of information for support?
A. technological B. cultural/ethical
C. economical D. all of the above

_____ 4-3B. When preparing for a debate, your information should come from
A. only those sources that support your side of the argument
B. only those written by technological experts
C. a variety of sources from both sides of the argument
D. a variety of sources supporting your side of the argument

_____ 4-3C. When developing debate strategies, the purpose of your arguments are used for what purpose in regards to your opponent?
A. persuade
B. educate
C. inform
D. all of the above

_____ 4-3D. Debates on technological issues are important because
A. the selection or non-selection of a technology can have political impacts
B. both side of the issues can be researched and formulated
C. so that there is always a winner over the issues
D. all of the above

_____ 4-3E. Which statement is true regarding the availability of information?
A. all information in written and electronic format have been carefully screened for accuracy
B. the same information can be used to support or oppose a technology
C. there exists in written and electronic format a multitude of misinformation
D. both B. and C. apply

Unit 4: Lesson 4 **Protecting Technology**

_____ 4-4A. Technological innovations and inventions are created to protect what type of property?
A. real
B. intellectual
C. personal
D. all of the above

_____ 4-4B. The recipe for Coca-Cola, which protection has no time limits, is known as
A. trademark
B. trade secret
C. copyright
D. patent

_____ 4-4C. Trademarks may include
A. product names
B. logos
C. package designs
D. all of the above

_____ 4-4D. The type of patent that protects a product, process or concept, are what type?
A. design
B. plant
C. utility
D. functional

_____ 4-4E. Technology protections are important to
A. in making sure companies receive money for their products
B. encourage people to be creative by rewarding them for the process
C. allow advertisers to make a profit from companies
D. all of the above

Unit 5: Lesson 1 Weighting and Prioritizing Design trade-Offs

_____ 5-1A. When evaluating a product design parameter, the most important
A. is the cost
B. is functionality
C. is aesthetics
D. depends on the product

_____ 5-1B. Weighting the parameters of a product design is ultimately based on
A. subjective thinking
B. precise analysis
C. feedback on product use
D. precise measurements

_____ 5-1C. Which of the following mathematical tools can be used to model a physical or social phenomena?
A. tables
B. matrices
C. charts
D. all of the above

_____ 5-1D. Decision options, based on design parameters, cultural values, risks and benefits, and the optimization process, are called
A. economic analysis
B. trade-offs
C. decision trees
D. product branches

_____ 5-1E. The ultimate, best product design is characterized as
A. valuable for all groups of people
B. usable by all people
C. A. *and* B.
D. simply not possible

Unit 5: Lesson 2 Using Models, Simulations and Games

_____ 5-2A. What type of model that behaves similar to the device it is modeling?
A. analog
B. iconic
C. verbal
D. mathematical

_____ 5-2B. What type of model that looks like what it represents, but does not behave the same?
A. analog
B. iconic
C. verbal
D. mathematical

_____ 5-2C. What type of model uses symbolic representations, and allows the modeler to change one variable?
A. analog
B. iconic
C. verbal
D. mathematical

_____ 5-2D. Specialized games that recreate real-world conditions are called
A. games of chance
B. simulations
C. games of skill
D. combinations of chance and skill

_____ 5-2E. Models are used to represent what type of phenomena?
A. mathematical
B. social
C. physical
D. all of the above

_____ 5-3A. Technology assessment should occur
A. during the design process
B. during the implementation of the technology
C. after the technology is in place
D. during both A. and B.

_____ 5-3B. Which is true of the U. S. Office of Technology Assessment?
A. the U.S. never had such an office
B. the office was created in 1972, but was dismantled in 1995
C. the office was created in 1972 and continues to serve as an advisor
D. the office was created in 1960, but was quickly privatized

_____ 5-3C. Technology assessment may be used to
A. identify existing or potential impacts of a technology device or process
B. identify alternative technologies or processes fro achieving the same goal
C. identify areas that require further research
D. all of the above

_____ 5-3D. Impacts that need to be minimized are
A. positive-intended B. positive-unintended
C. negative-intended D. negative unintended

_____ 5-3E. Impacts that need to be maximized are
A. positive-intended B. positive-unintended
C. negative-intended D. negative unintended

Unit 5: Lesson 4 **Applying Technology Forecasting/Futurology Tools**

_____ 5-4A. Which of the following mediums is used to predict the future?
A. movies B. art
C. literature D. all of the above

_____ 5-4B. A prediction technique that looks at current and past observations is called
A. extrapolation trends B historical trends
C. systematic generation of alternatives D. collective opinions

_____ 5-4C. A prediction technique that can be qualitative or quantitative is called
A. extrapolation trends B historical trends
C. systematic generation of alternatives D. collective opinions

_____ 5-4D. Collective opinion predictions use which type of tool?
A. surveys B. Delphi technique
C. market research D. all of the above

_____ 5-4E. A prediction tool that attempts to get consensus from a group of experts is called
A. survey B. Delphi technique
C. futures wheel D. historical analysis

Appendix F
Reviewers

ITEA-CATTS wishes to express special thanks to the following field reviewers who provided valuable feedback in the development of this resource:

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